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PAPER No. I.

THE CO-OPERATIVE SOCIETIES ORDINANCE 1931.

BY A. W. PATERSON.

In view of the local importance of the recently passed Co-operative Societies Ordinance and as there is a Schedule of Rules made under this Ordinance which qualifies many of its provisions, it is felt that a summary in which the main points of this legislation are discussed would be useful. The main provisions of the enactment are dealt with in the order in which they occur, but where any Rules qualify these provisions, references to these are embodied in the discussion of the section to which they refer.

The purpose of co-operative legislation is to take co-operative societies out of the operation of the general law and to substitute provisions specially adapted for their constitution and objects. Secondly, it is desired to confer upon them privileges and facilities in order to encourage their formation and to assist their operation. Finally, it is necessary to take precautions to prevent speculators and capitalists from availing themselves under colourable pretexts of these exemptions from the general law and of privileges not intended for them.

The first section of the Ordinance states that this enactment shall be known as the Co-operative Societies Ordinance No. 4 of 1931, and the second gives the legal interpretation to be placed on certain words which occur in the Ordinance.

REGISTRATION OF SOCIETIES.

Section 3 provides for the appointment, by the Governor, of a Registrar of Co-operative Societies and of Assistant Registrars.

The use of the term " Registrar " must be regarded as an unfortunate choice of a title as it is usually understood to imply that the person so designated is merely a " recorder " or " keeper of records," whereas the duties of the Registrar of Co-operative Societies cover a very much wider field. As we shall see, the Registrar of Co-operative Societies must satisfy himself that not only

must a society which he proposes to register comply with the provisions of this Ordinance but he should also be certain that it is honest in its intentions. In addition to receiving annual statements of accounts, he is entrusted with the statutory duty of audit and is given wide powers of inspection so that he is responsible that any registered society conducts its business in an honest and straightforward manner. Moreover, summary powers of liquidation are provided for and the Registrar is given executive as well as administrative powers. In connection with disputes arising out of the business of societies the Registrar may refer these to arbitration with right of appeal to the Registrar later, or settle them himself, and in either case his decision is final and conclusive. In addition to these statutory obligations, the actual duties of the Registrar are to encourage the formation of societies and to foster and guide the growth of the co-operative movement generally.

Section 4 gives authority for the registration of any society that aims at promoting the economic interests of its members in accordance with co-operative principles, and provides that such societies may be registered as having either limited or unlimited liability. Thus the societies which may be registered can be divided into two broad classes. Those where the liability of the members is limited to the face value of the shares subscribed by them. Secondly, where unlimited liability is accepted, each member accepts responsibility for the debts of the society to the full extent of his real or immovable property, his chattels or movable property, and his personal credit or general reputation for thrift and honesty. In order that the public shall know what type of liability has been accepted by the members of a society it is laid down in the third sub-clause of the next section that the last word in the name of any society of limited liability shall be the word " Limited."

The conditions which must be complied with before a society can be registered are prescribed in Section 5 : the society must consist of at least 10 persons above the age of 18 years, who reside on or occupy land within its proposed area of operations. The minimum age limit is insisted upon to prevent the formation of " straw " societies, i.e., where an unscrupulous person could band together a number of children and then apply for registration as a co-operative society when it is obviously a " one-man show." The minimum membership is 10 and, if through any cause it falls below this number, the Registrar may cancel the registration of the society as provided in Section 36. The provision that the members of a society must " reside on or occupy land within its proposed area of operation " is a very important one from the co-operative point of view. It is essential that members of a co-operative society should know and be able to trust one another, otherwise, they cannot work together to attain their object. To ensure this, a society in its by-laws must state its proposed area of operation and this, in the case of primary societies particularly, should be as

small as possible so that members may know each other and their actions intimately. The generally accepted unit is the village. The first Rule in the Schedule attached to the Ordinance lays down the further condition for registration that each member must have agreed to acquire such an interest in the society as will entitle him to membership.

The second sub-clause of Section 5 provides for the settlement of any question which may arise as to the qualification of any person for membership of a society, by the Committee of the society. Where that body is unable to decide, the matter shall be referred to the Registrar whose decision shall be final. One of the great benefits that co-operative legislation confers on societies is the power given the Registrar of summary settlement of such matters as this. It prevents the possibility of a litigiously-minded person, who is only too frequently found in almost all tropical countries, carrying some petty contention to a Court and involving both the society and himself in unnecessary expense.

Section 6 deals with the procedure to be followed by a society desiring to be registered as a co-operative society. An application for registration on Form A as prescribed in Rule 2 of the Schedule, signed by at least 10 duly qualified persons, should be submitted to the Registrar together with two copies of the proposed by-laws of the society. Societies are given powers to make and to amend by-laws, provided certain conditions are complied with under Rules 9, 10 and 11 made under sub-clause (2) (*l*) of Section 43 of the Ordinance. Rule 9 lays down that every society shall make by-laws in respect of such matters as are prescribed in its 26 sub-heads. The persons applying for the registration of a society are bound to furnish such information in regard to the society, particularly as to its aims and objects, as the Registrar may require.

The next section provides that if the Registrar is satisfied that the society applying for registration has complied with, and that its proposed by-laws are in accordance with, the provisions of the Ordinance and of any Rules made thereunder, he may, if he thinks fit, register the society and its by-laws. The Registrar is here given very wide discretionary powers for not only must he be satisfied that the society complies and intends to comply with the provisions of the Ordinance but even then he can defer the registration of any organization about which he is in any way doubtful. While this puts the Registrar in a very strong position, at the same time it increases his responsibility because given such wide powers, there is no possible excuse for a society of a wrong type being registered. On registering a society the Registrar shall issue a certificate of registration which according to Section 8 shall be conclusive evidence that the society mentioned therein and its by-laws have been registered, unless the registration of that society has since been cancelled.

No amendment to the by-laws of a society shall be valid until registered by the Registrar who shall issue to the society a copy of the amendment certified by him which shall be proof that the amendment has been registered. The Registrar must satisfy himself that the amendment proposed is not contrary to the Ordinance and that the proposal comes within the scope of the by-law-making powers granted to societies under Rule 9. Moreover the Registrar must be satisfied that the provisions of Rule 10 have been complied with, namely, that due notice of the proposal had been given to members, that a quorum of at least half the members of the society were present at this general meeting, and that of those present at least three-fourths were in favour of the amendment.

RIGHTS AND LIABILITIES OF MEMBERS.

Under the main heading of " Rights and Liabilities of Members " it is laid down that a member of a registered society shall not exercise the rights of membership until he has paid such entrance fee and acquired such interest in the society as may be prescribed. Rule 1 prescribes that where the capital is raised by shares, a member must take at least one share. Societies, however, under the by-law-making powers conferred on them by Rule 9 (*d*) can increase the number of shares requisite for membership.

Section 11 lays down that no person shall be a member of more than one society of unlimited liability without the approval of the Registrar. It is obvious that a person cannot pledge everything he possesses—his movable and immovable property and his personal credit—more than once, and the exceptional case of a wealthy person who could, if necessary, clear off the debts of a society of which he was a member without ruining himself is provided for by the proviso.

In order to prevent any individual from obtaining control of a society, Section 12 prescribes that where the liability of members is limited by the value of shares held by them, no member shall hold more than one-fifth of the share capital. It is obvious that a member having control of an unduly large proportion of a society's capital would be in a position to coerce the society by giving them the alternative of adopting his views or of having the society left with very little capital as the result of his withdrawal.

The are certain restrictions in Section 14 to the transfer of the shares held by members in a co-operative society. A member cannot transfer any shares held by him so long as he remains a member of the society, nor can he do so until he has held such shares for at least one year and the transfer must be made to the society or to another member. That is to say shares in a co-operative society cannot be held by persons who are not members.

It is definitely laid down in Section 13 that a member shall have only one vote in the affairs of the society no matter what number of shares he may hold. One man, one vote, is one of the essential principles of co-operation and has given rise to the definition of a co-operative society as a " union of persons " as compared with a joint stock company which is a " union of capital " as in the latter the voting power is in proportion to the number of shares held. Moreover, voting by proxy on any matter whatever, is definitely forbidden by Rule 8. Proxy voting is always dangerous and undesirable under any circumstances and its complete prohibition will no doubt prevent many abuses which might otherwise have occurred.

THE DUTIES AND PRIVILEGES OF REGISTERED SOCIETIES.

Each society shall have a registered address (any change in which must be notified at once to the Registrar), where copies of the Ordinance, the Rules and the By-laws of that society shall be open for inspection, free of charge, at all reasonable times. This provision is a usual one with which all organizations registered under a legal enactment have to comply. The object is that any person who may wish to have any dealings with such organizations shall have access to their articles of constitution and so can act with full knowledge of his position.

The registration of a society renders it a corporate body under the name by which it is registered. That is to say it can carry on business, hold property, enter into contracts, take or defend action in Court, and do all necessary things for the purposes of its constitution under its registered title under Section 17 of the Ordinance.

Section 18 confers on registered societies the right to a first charge on possessions of members, provided these things have been purchased or grown by means of a loan from the society. A proviso protects any bona fide purchaser of such things. Societies have the right to charge and set off the debts of a member against any share or interest held by that member. This is a very beneficial provision from the point of view of a society. If a member holds shares to the value of say, £5, and he obtains a loan from the society which he does not repay, this sum of £5 can be set against his loan and so the loss to the society is reduced.

The shares purchased by a member in a registered society are not liable to attachment under any decree of a Court or Tribunal. This provision is not intended to and will not provide a haven for funds wrongfully obtained by some member, but is designed to provide security for the funds of societies.

On the death of a member his share or interest in a society may be transferred to the heir of the deceased or to the representative of his family, in accordance with the Native Customary Law on inheritance, as the case may be. In the case of societies with unlimited liability the society may require to pay to the heir or representative the value of these shares, but in the case of a society with limited liability the society may transfer the shares to the heir or representative, if he is qualified to become a member and desires to do so. All other sums due to a deceased member shall be paid to his heirs and any payments made by a society to an heir or representative shall be valid against any claims made by other claimants. Rule 4 prescribes the mode of determining a deceased member's interest by charge and set-off as empowered by Section 19 of the Ordinance.

When a member resigns from a registered society, he is still liable until the expiration of two years, for the debts of the society as they existed when he ceased to be a member. The estate of a deceased member is liable for a like period. This provision is intended to prevent members deserting a society which has got into debt and abandoning it or leaving only a very few members with all the responsibilities. It still enables a member who disagrees with the policy of a society which he thinks may lead it into debt, to resign before he has incurred any liability in connection with any unsound scheme.

Section 24 provides that any register or list of members kept by a registered society shall be prima facie evidence of the date on which any person became a member or ceased to be a member. The next section prescribes that a copy of any entry in a book of a registered co-operative society shall be admitted as evidence in any Court as prima facie evidence to the same extent as the original entry is now admissable. Rule 15 prescribes that copies of such entries in a society's book shall be certified as correct by the Secretary and another officer of the society or a member of the Committee. This provision is a very useful one as it prevents the business of a society being held up when its books are required as evidence in any Court, a copy of the entries required, duly certified, being sufficient.

EXEMPTION FROM TAXATION.

Section 26 provides that the Governor in Council may remit any registration fee payable under existing legislation as well as the stamp duty on bonds, deeds, contracts, etc., made by a society in course of its business. The remission of this taxation is one of the methods which have been adopted by Governments to encourage the development of co-operative societies. The actual remission may not amount to a very large sum but from an administrative point of view it is of very great benefit to small societies composed

very largely of illiterates. Such persons generally would not understand why they should pay these amounts to Government in order to transact their business. Moreover, the collection of such sums would be laborious and these difficulties would definitely hinder the organization of such a system of co-operative societies as is projected in the Gold Coast.

PROPERTY AND FUNDS OF REGISTERED SOCIETIES.

It is definitely laid down that a co-operative society shall not make a loan to any person who is not a member of that society although it may make a loan to another registered society provided the Registrar's consent has been received. A society is prohibited from lending money on the security of a mortgage on immovable property and shall not lend on the security of movable property without the permission of the Registrar. One of the basic principles of co-operation, that loans shall only be made on personal security and surety, is here enforced. An ordinary small co-operative society, with a membership of simple, and most probably, illiterate peasants is unable to undertake the complicated legal processes necessary to lend money on mortgage and has no facilities for the safe keeping of trinkets or other valuables which members may desire to pledge.

Section 28 prescribes the restrictions to the borrowing of funds by societies. A society can receive deposits from its members without restriction as each member ought to have full knowledge of the society's position and in event of any loss can only blame himself. A society, however, can only borrow from other than members subject to a limit to be fixed from time to time by the Registrar in accordance with Rule 6.

In Section 29 the Governor in Council reserves the right of prohibiting or restricting the transactions of a registered society with persons other than its own members. This provision is designed to prevent societies from becoming involved in dealings with persons or firms who might desire to take advantage of the ignorance or credulity of the members of societies.

Societies are required to deposit their funds in banks or with bankers approved by the Registrar. In well developed countries this might be alleged to be an unnecessary restriction but in view of recent happenings in West Africa, it is very desirable.

Clause 31 deals with the disposal of any profits made by a registered society. The aim of a co-operative society should be to perform some service to its members at the cheapest possible rate, and under these conditions a society should make no profit. While that is a very sound theory it is almost impossible to achieve in practice, as in order to protect itself from loss and to provide for reserve and other funds, it is necessary to charge slightly more than the bare cost for these services. No distribution of profits can be

made to members as bonus or dividend until at least one-quarter of the total net profit has been set aside for the formation and maintenance of a Reserve Fund. Rule 18 lays down that no payment on account of profits shall exceed $7\frac{1}{2}$ per cent per annum on share capital. No society of unlimited liability shall make any distribution to members on account of profits without the written consent of the Registrar. This can only be given provided the provisions of Rule 5 have been complied with. This rule provides that the Reserve Fund shall be at least equal in amount to one-tenth of the total liabilities of the society, and that the rate of interest on loans to members shall not exceed 10 per cent per annum.

AUDIT AND INSPECTION OF SOCIETIES.

It is laid down that the Registrar shall audit the accounts of every society or shall cause them to be audited at least once in every year by some person who is not an officer of the society. This audit shall include an examination of overdue debts, if any, and the valuation of the assets and liabilities of the society. Rule 12 prescribes that each co-operative society shall prepare before 31st May, each year a balance sheet showing the income, expenditure and the profits of the society for the year ending 30th April and this return will also include a statement of the assets and liabilities of the society on the latter date. After audit the Registrar shall publish these returns. Under sub-clause (3) of Section 32 a society may, if it so desires, appoint its own Auditors but their work shall be additional to, and shall not replace, the statutory audit.

Under Section 33 the Registrar and Assistant Registrars are given access to all books, papers, cash, etc., belonging to a registered society and all officers of a society are required to furnish such information as the person making an inspection may require. The Registrar is also given the right to hold an inquiry into the constitution, working and financial condition of a society, and he shall hold such an enquiry on the application of a majority of the Committee, or of not less than one-third of the members of a society. Moreover, a creditor of a registered society can demand that the books of the society shall be inspected, provided he satisfies the Registrar that the debt is overdue, and provided the creditor deposits with the Registrar such a sum as security for the cost of the inquiry as the latter may require. The Registrar shall communicate the results of such an inspection to the creditor. Where an enquiry has been held at the request of the committee or the members, or an inspection at the request of a creditor, the Registrar may apportion the costs between the society, the members demanding the enquiry, or the creditor making the application, and the officers or former officers of the society. Any such costs may be recovered by the distress and sale of any movable property belonging to the person from whom such sum is claimed, on application to the Court having jurisdiction.

THE DISSOLUTION AND LIQUIDATION OF A REGISTERED SOCIETY.

If the Registrar, after holding such inquiry or making such inspection as is mentioned in the previous paragraph, or, on the application of three-fourths of the members of a society, is of the opinion that the society ought to be dissolved, he may cancel its registration. Any member of a registered society may, within two months from the date of such an order, appeal from such order to the Governor. When no appeal is presented within two months from the date of the order cancelling the registration of the society, the order shall take effect from the expiry of that period. In cases in which an appeal is made, the order shall not take effect until confirmed by the Governor. The Registrar may cancel the registration of a society if at any time it is proved to his satisfaction that the number of the members has been reduced to less than 10. Such an order shall take effect immediately, and in all cases as soon as an order for cancellation takes effect, the society in question shall cease to exist as a corporate body. The Registrar can then appoint a competent person to be a liquidator of the society. The procedure in a case of liquidation of a co-operative society, has been specially simplified and the liquidator has been given wide powers so as to secure efficiency and despatch at low cost. All Courts and Tribunals are deliberately excluded from any civil jurisdiction in this matter except where these are specifically mentioned. A liquidator can take legal proceedings, if necessary, on behalf of the society by the name of his office. He can summon and enforce the attendance of witnesses, and compel the production of documents in the same manner as is provided for in the case of civil cases under the Supreme Court Ordinance. Orders made by the liquidator shall be enforced in the same manner by the Court as an order made by that Court. The liquidator is authorized to determine the contribution to be made by members or past members to the assets of a society ; to investigate all claims against the society, and decide questions of priority amongst claimants ; to determine by whom and in what proportions the costs of the liquidation shall be borne, and shall give such directions in regard to the collection and distribution of the assets of the society as may be necessary in winding up the affairs of the society.

SETTLEMENT OF DISPUTES BY ARBITRATION.

All disputes touching the business of a society, which may arise between a member or a past member or any one claiming through such persons, and a registered society or its committee or any of its office-bearers, shall be referred to the Registrar for decision. A dispute shall include claims by a society for debts due to it by a member or past member. The idea of incorporating such provisions in a Co-operative Societies Ordinance is to prevent societies from

being put to heavy and unnecessary expense through the perversity of a litigious member. The Registrar on receiving notice of such a dispute shall either decide the dispute himself or refer it to the arbitration of two arbiters, one to be appointed by each party to the dispute. If either party fails to nominate an arbiter within 15 days from the receipt of the Registrar's notice, the Registrar himself may make the nomination. In these proceedings the statements of the parties and of their witnesses shall be reduced to writing and after consideration of any documentary evidence, a decision or award shall be given in accordance with justice, equity and good conscience. In these proceedings neither party shall be represented by a legal practitioner.

Any party aggrieved by an award of arbiters may within one month appeal to the Registrar whose order thereon shall be final and conclusive. The award of arbiters or a decision by the Registrar shall not be liable to be called in question in any civil court. Where the decision or award involves the payment of money or delivery of produce and such payment or delivery is not made within one week, the Registrar shall send a record of the proceedings to the District Commissioner's Court or the Police Magistrate's Court having jurisdiction and such court shall enforce the decision or award as if it were a decree of that Court.

RULE-MAKING POWERS AND OTHER MISCELLANEOUS PROVISIONS.

Powers to make Rules for the better carrying out of the Ordinance are conferred on the Governor in Council with the consent of Legislative Council in Section 43. The provision that the consent of Legislative Council is necessary before rules can become effective is, I believe, most unusual but it was inserted in this Ordinance at the request of the African Unofficial members of the Legislative Council, so that they should have a voice in the making of any future rules. That Rules made under an Ordinance should pass Legislative Council is unusual and it arose in this Colony through the adoption of that procedure in Ceylon where the unofficial members refused to pass the empowering Ordinance without the Rules being presented to them. This Colony copied that procedure and has now gone a step further by laying down that when any Rules are made the consent of Legislative Council must be obtained.

Section 44 provides that the Government may recover sums due to it from a registered society, firstly, from the property of a society, secondly, in the case of a society with limited liability from the members subject to the limit of their liability, and thirdly in the case of societies of unlimited liability from the members.

The Governor in Council by virtue of Section 45 may exempt a society from any of the provisions of the Ordinance or modify these provisions to suit some special circumstances. This power gives elasticity to the movement and allows modifications of conditions governing societies to be effected, without resort to the lengthy and tedious process of amending the Ordinance.

The use of the word " co-operative " as a title or name is restricted to societies registered under this Ordinance but any organization using the word when the Ordinance came into force may continue to do so.

The final clause states that the provisions of the Companies Ordinance shall not apply to societies registered under this Ordinance.

PAPER No. II.

HINTS ON FORMING CO-OPERATIVE SOCIETIES.

By J. McN. WINGATE.

(These notes were prepared by Capt. J. McN. Wingate as a guide to officers engaged in the new activity of founding agricultural co-operative societies. They are the result of experience and are reproduced here because of their value to other workers.—Editor.)

It has been found advisable to study a larger scale map of the area to be worked before going out into the field. Decide from the map the order in which villages will be visited. The larger villages are generally on motor roads and should be taken first.

Call on the Omanhene of the division and explain to him the co-operative movement, and the work it is proposed doing in his division. Request him to use his influence with his chiefs on behalf of the movement.

Each village should be visited and meetings arranged. Ask the chief to call a meeting of farmers on one of the days when they come into the village from their farms (farmers generally come in from their farms two days every week), and impress upon him the necessity for the meeting to be well attended.

The following points might be brought up at these meetings :—

(*a*) The purity of Gold Coast cacao is lower than that of Ceylon, Java, and West Indies. In those countries the farmers get a higher price for their cacao because they have prepared it much better than the Gold Coast farmers have done. They have harvested their pods at the proper time, and have thus reduced the percentage of germinated beans. Also their farms are larger and their output greater which makes it possible for the merchant to buy large bulks of cacao, whereas in the Gold Coast he is compelled to collect small lots. The organization required for this work in the Gold Coast is a very costly one for which the farmer indirectly pays. If farmers in each village collected their small lots into one large bulk, merchants could dispense with the services of the small broker, and would be in a position to pay the farmer that amount extra which hitherto he has paid out in brokers' commission.

(*b*) At present there is over-production of cacao in the world, which almost certainly will mean that in the future merchants will concentrate more on quality than they have done in the past. It is, therefore, not unlikely that from now onward the buyer will only accept properly prepared cacao and that he will tell the farmer to throw his poor quality beans back on the farm. This has occurred in other countries so there is no reason why it should not happen here.

(*c*) It is quite possible that the merchant will offer a premium for quantity as well as exact a penalty for low purity.

(*d*) If the Gold Coast farmer desires the cacao industry of this Colony to be a continued financial success he must firstly effect considerable improvement in quality, secondly, increase the yields from existing acreage and, thirdly, do all in his power to reduce the high cost of local marketing.

(*e*) Government realising the serious position of the cacao industry has introduced into the Colony the co-operative movement. The objects of this movement are briefly as follows :—

(1) To promote thrift amongst farmers.

(2) To improve the general condition of cacao farms.

(3) To improve purity by better preparation.

(4) To reduce local marketing costs by bulking small lots of each village.

(5) To improve storage conditions in villages.

(6) To create facilities to enable farmers to borrow money for legitimate purposes at low rates of interest.

(7) To enable advances* to be made free of interest to farmers against cacao in village stores.

(*f*) In order to operate the above schemes it is necessary for farmers of each village to group themselves into a unit called a Co-operative Society. These societies are run as follows :—

(1) At least 10 farmers of the village must enrol before a society can be formed.

(2) Each farmer who wishes to join such an unit must pay 1s. as an entrance fee and must take out at least one (1s.) share. In practice, it has been found that the average farmer agrees to take shares to the value of 5s. on enrolment (some have subscribed 20s. and some 10s.).

(3) When 10 farmers have agreed to form a society a meeting is held and they elect their own President, Vice-President, Secretary, and Treasurer.

*This is not really an advance, but a spot cash payment by a society to a member on receipt of his cacao.—Editor.

(4) Farmers must pay their entrance fee and subscriptions to share capital before enrolment.

(5) Members must agree to sell all their cacao through their society and must run their society in accordance with the by-laws.

(6) Each member should subscribe regularly every month an amount which he or she can afford. The more capital subscribed to the society's funds when available the more can he borrow when times are hard.

(7) All money subscribed by members is placed in the nearest Bank in the society's name at the usual rates of interest.

(8) No money can be withdrawn without the consent of the society.

(9) When sufficient capital has been subscribed the society should build a suitable store in which to bulk the members' cacao. This store is the property of the society and does not belong to Government. Such a store would enable farmers to keep their cacao in the village until a favourable selling opportunity presented itself without much fear of deterioration in purity. At present many farmers are forced to sell their produce before they desire to because they know that to keep it, even for a short time, in the unsatisfactory stores which they have at present, would certainly increase the percentage of defects.

(10) Provided members subscribe regularly, money would also be available for the purchase of cacao bags, sacks, needle and twine in the first year, and, later on, the society should be able to purchase an accurate weighing machine. All the above articles are necessary for the proper marketing of cacao.

(11) Members must agree to the examination by a Government officer of all cacao brought into a society's store, and must understand that no cacao will be admitted unless it has been thoroughly dried and well prepared. This ensures that only cacao of a high purity will be sold through a society, which almost certainly will result in higher prices to members.

(12) Members must clearly understand that they will receive a printed receipt* for all monies paid into the society, and also that all subscriptions to share capital must be entered in ink in the pass-book which is issued to them on enrolment. Receipt and all entries in their

*An entry in the pass book is valid.—*Editor.*

pass-books must be signed by the Overseer-in-charge of the society or by the European-in-charge of the area. It must be stated on the receipt whether the payment is in respect of entrance fee or shares.

(g) The following procedure has been found satisfactory when holding monthly meetings of societies :—

(1) Read out minutes of last meeting (minutes of all meetings should be taken by overseer).

(2) From duplicates in receipt books read out to members amounts subscribed during the month and get members to verify.

(3) Read out from the Share Register the total amount subscribed in shares by each member to date.

(4) Explain financial position of society from Cash Book giving full details of Receipts and Expenditure.

(5) Encourage subscriptions.

(6) Call for questions.

(7) Advise members when next meeting is likely to be held.

GENERAL.

It will be found that the forming of societies is not an easy task, and that many difficulties will be met with. In most districts farmers will at first regard the co-operative movement with suspicion and will think that Government, through its officers, are playing into the merchants' hands, or in other words that the Department of Agriculture is on the buyers' side and against the farmers.

It is only by experience that farmers will realize how much they are mistaken, and whether they do or not depends on the thoroughness and sincerity with which the officers on this work perform their tasks.

Officers must be prepared to meet many obstacles and should realize that in co-operative work in this country the line of least resistance is over these obstacles and not round them.

Many visits may have to be made to a village before a society is formed, in fact very rarely is one able to reap the fruits of labours after one meeting. Very often the villages which show least promise in the beginning are the ones from which the best results are eventually obtained. All these factors tend to make the task more interesting, because something which is achieved with little effort is not to be compared with success after a hard fight. Officers who agree with this statement will find co-operative work in the Gold Coast well worth the while.

PAPER No. III.

WORK OF CO-OPERATIVE SOCIETIES DURING 1930-31.

By J. C. MUIR.

INTRODUCTION.

Up to 30th April, 1931, 116 co-operative societies have been formed, of which 113 are Cacao Producers Co-operative Societies, one a Rice Growers Society, and two are Thrift and Loan Societies. Of the Cacao Societies, 41 operated during the whole or part of the cacao season 1930–31. All of those which were in existence during 1929–30 continued their activities during 1930–31, but Abokobi Food Crops Society was not supervised by the Department of Agriculture during the year, as its aims no longer remained of a purely co-operative nature.

INCREASE IN NUMBER OF SOCIETIES, MEMBERSHIP AND CAPITAL SUBSCRIBED.

Appendix A presents a summary of the financial position of each society which worked during the year under review, while Appendix B gives the name, membership and amount of capital subscribed, to 30th April, 1931 by each Cacao Producers Society formed in readiness for the season 1931–32.

In the accompanying map the position of co-operative societies is indicated by a red spot.

In the table below, the total number of societies, membership and amount of capital subscribed by members is shown for the years 1929–30 and 1930–31.

Period.	Number of societies.	Total Membership.	Amount of capital subscribed.
			£ *s.* *d.*
1929–30	31	946	1,328 16 0
1930–31	116	2,176	1,707 19 0

It will be seen that the number of societies has increased by 85, the membership by 1,230 and the amount of capital by £379 3s. during the year ending 30th April, 1931.

FORMATION OF NEW CO-OPERATIVE SOCIETIES.

This progress is a direct result of intensive propaganda carried out by members of the Department of Agriculture, and by officers of the Political Administration seconded for such work. The formation of new societies, and especially the accumulation of share capital, has been a matter of considerable difficulty at a time when the farming community is financially embarrassed as a result of the low prices recently paid for cacao, but it is expected that the new societies will subscribe capital during their first year of working.

REVENUE FROM SALE OF CACAO.

The revenue from the sale of cacao was again greatest in the Kumasi area, but the total revenue from all Cacao Producers' Societies dropped during the year despite the fact that the quantity of cacao sold was higher in this than in the previous year. The following table shows the membership, quantity of cacao sold, and revenue obtained by the 27 cacao societies which functioned during 1929–30, and similar data for the same societies during 1930–31.

Year.	Membership.	Quantity of cacao sold. (Tons).	Revenue derived from sale of cacao.
			£ s. d.
1929–30	724	354.6	10,730 18 8
1930–31	743	516.2	8,293 17 7

While the membership of these societies has risen slightly during 1930–31, the increase in the quantity of cacao sold is out of all proportion to the increase in membership. This is easy of explanation. Most of the members who had held back part of their cacao during 1929–30 through incomplete understanding of co-operative principles and doubts as to the safety of combined marketing, have now had their fears allayed, and, consequently, they are marketing more of their crop through their societies. In the case of a few societies, less cacao was sold during 1930–31 than during 1929–30. In such cases the retrogression was due to the inability of the Department of Agriculture to provide adequate supervision and to the effect of the hold-up of cacao during the season. The year 1930–31 was a poor one for farmers : the price of cacao fell to a level undreamed of, and, on the part of the producers, there was a widespread effort to counteract this by refraining from selling their cacao until a better price was obtained. Cacao Producers' Co-operative Societies were, in some cases, a party to this hold-up, and as money became scarce individual members tended to sell cacao privately to raise ready money. Despite the instances mentioned, the loyalty of the majority of members towards

their societies is to be commended. This is clearly reflected in the increased quantity of cacao sold by the 27 societies mentioned previously. Appendix C gives the average size of lots of cacao sold by members of co-operative societies.

EXPENDITURE.

Expenditure as in previous years was incurred principally by the erection or rent of stores, by the purchase of bags and stationery and by the hire of transport. In the Department of Agriculture Society, expenditure was accounted for by the purchase of canteen stores.

PROFITS AND LOSSES.

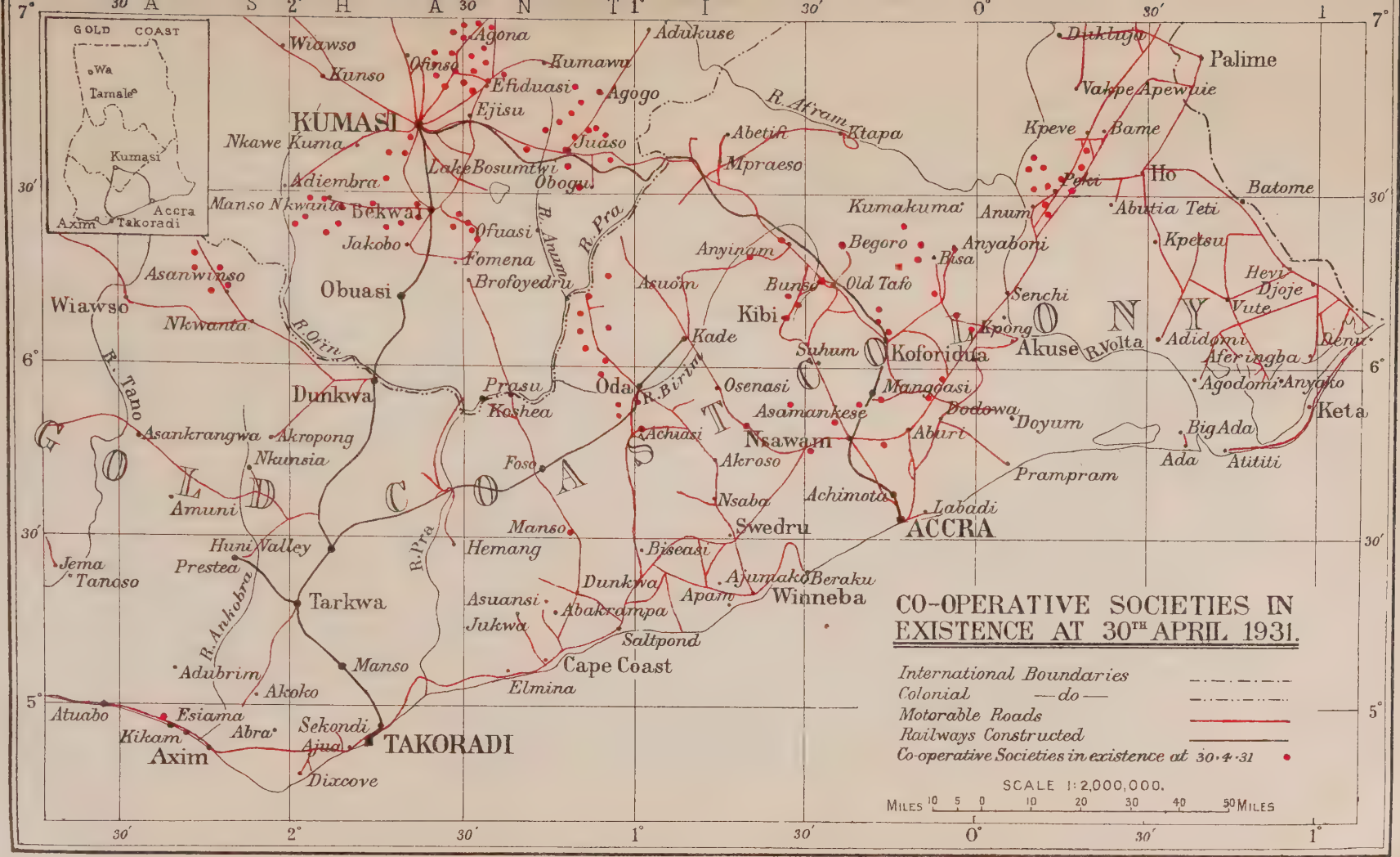
Profits in the case of Cacao Producers' Societies were derived chiefly from deductions made by the societies in respect of cacao sold by members. These deductions varied from 3d. to 6d. per load. Other sources of income were interest on bank deposits and interest on loans to members, the latter item being on the increase. The society at Akotue has been inert since its formation and will probably be disbanded at an early date. The losses made by societies in the Oda area were occasioned by the depreciation of large stocks of equipment, and this group, which is well equipped, is expected to show an improved position during 1931–32.

DIVIDENDS.

Where profits have been made, a dividend not exceeding $7\frac{1}{2}$ per cent of the subscribed capital has been paid to members. Those societies in the Kumasi area which had brought forward surplus profits from the previous year added these to the profit made during the year, and dividend was paid from the gross profit. Other societies paid dividend from the net profits made during the year, and continued to carry forward surplus profits from the previous year.

PREMIUM OVER CURRENT PRICE.

During the year, societies in the Oda and Bisa areas received a premium of 9d. per load and those in Ashanti a premium of 6d. per load over current prices.



Survey H.Q. Accra, 1931.

APPENDIX A

Name of Society.	Date formed.	No. of Members.	Paid-up Capital. £ s. d.	Revenue from sale of cacao. £ s. d.	Expenditure. £ s. d.	Profit shewn at end of year. £ s. d.	Loss shewn at end of year. £ s. d.	Amount placed to Reserve Fund during year. £ s. d.	Total Reserve Fund. £ s. d.	Dividend paid. £ s. d.	Quantity of cacao sold. Tons.	Store owned or rented.
CACAO PRODUCERS' MARKETING SOCIETIES. BISA AREA (EASTERN PROVINCE).												
Dawa Sutchoom	Aug., 1929	20	12 19 0	263 5 8	2 17 6	21 6 2	—	3 10 10	3 10 10	0 19 6	18.0	Owned
Kabo	Aug., 1929	15	6 17 0	38 1 5	0 18 4	2 19 2	—	0 10 0	0 10 0	0 10 3	2.8	Rented
Huhunya ...	Aug., 1929	23	11 5 0	46 10 5	6 19 3	5 3 11	—	0 6 3	1 15 10	0 16 10	3.4	Rented
Odometa ...	May, 1929	45	22 15 0	94 0 0	22 6 0	5 10 3	—	0 18 4	0 18 4	1 14 2	6.8	Owned
Obawale ...	Aug., 1929	30	38 9 0	535 2 8	55 10 6	38 11 7	—	9 12 11	9 12 11	2 17 8	25.1	Owned
Prekumasi ...	July, 1929	17	10 10 0	202 14 6	6 7 0	10 6 2	—	2 7 9	2 7 9	0 15 9	12.8	Rented
Sutrisu ...	May, 1929	30	9 3 0	105 6 8	3 7 0	4 18 11	—	0 18 0	0 18 0	0 13 9	7.0	Rented
Cheredom ...	Feb. 1930	18	30 10 0	184 16 0	28 4 0	9 10 8	—	2 5 2	2 5 2	2 5 9	12.4	Owned
Akotue ...	July 1929	18	4 10 0	—	—	0 1 10	—	—	—	—	—	—
Jumwa ...	Sept., 1930	29	12 2 0	127 6 2	4 5 8	7 8 5	—	1 17 1	1 17 1	4 13 2	9.0	Owned
Nsuta	Jan., 1930	20	12 19 0	120 9 4	5 17 2	5 16 8	—	1 9 2	1 9 2	0 19 5	8.7	Rented
	Total ...	265	171 19 0	1,717 12 10	116 12 5	111 11 9	—	23 15 6	25 5 1	16 6 3	106.0	
PEKI AREA (EASTERN PROVINCE).												
Peki Abanase		24	62 9 0	320 7 3	11 4 4	—	1 18 11	—	—	—	21.5	Rented
NSAWAM AREA (EASTERN PROVINCE												
Obodan ...	Aug., 1915	39	46 16 0	30 12 6	7 19 6	—	2 16 1	—	1 8 0	—	1.9	Rented
Otoasi ...	Oct., 1929	14	11 8 0	128 5 0	7 15 11	5 19 0	—	0 13 7	2 0 0	0 17 0	8.0	Rented
	Total	53	58 4 0	158 17 6	15 15 5	5 19 0	2 16 1	0 13 7	3 8 0	0 17 0	9.9	

APPENDIX A.—*continued.*

Name of Society.	Date formed.	No. of Members.	Paid-up Capital. £ s. d.	Revenue from sale of cacao. £ s. d.	Expenditure. £ s. d.	Profit shewn at end of year. £ s. d.	Loss shewn at end of year. £ s. d.	Amount placed to Reserve Fund during year. £ s. d.	Total Reserve Fund. £ s. d.	Dividend paid. £ s. d.	Quantity of cacao sold. Tons.	Store owned or rented.
ODA AREA (CENTRAL PROVINCE).												
Oda	June, 1929	18	85 19 0	237 4 3	25 3 9	—	15 4 6	—	—	—	14.5	Owned
Akim Swedru	June, 1929	36	105 3 0	556 6 8	17 18 3	—	10 14 11	—	—	—	37.3	Owned
Ewusa... ...	Aug., 1929	30	112 3 0	854 8 0	35 12 4	—	14 19 5	—	—	—	51.0	Owned
Nkwanta ...	Aug., 1929	14	18 19 0	151 13 3	4 0 0	—	7 18 1	—	—	—	9.3	Rented
Nkwaten ...	Aug., 1929	12	34 18 0	126 11 3	7 17 5	—	1 12 5	—	—	—	10.8	Rented
Ntronang ...	May, 1929	29	42 11 0	217 7 0	0 13 0	—	5 5 2	—	—	—	20.3	Rented
Ntumtumerin	May, 1930	10	17 12 0	254 1 4	17 12 11	—	4 11 3	—	—	—	17.0	Rented
Brenase ...	July, 1930	17	13 8 0	84 7 6	9 9 6	—	4 3 10	—	—	—	6.0	Rented
Akokoas ...	July, 1930	10	11 3 0	66 5 4	10 8 10	—	2 10 11	—	—	—	5.1	Rented
Ofuaseo ...	Aug., 1930	15	11 15 0	104 4 3	10 17 3	—	2 18 7	—	—	—	7.5	Rented
Abenase ...	Aug., 1930	11	7 6 0	49 11 6	10 2 11	—	3 17 9	—	—	—	3.0	Rented
Ayirebi ...	Sept., 1930	11	8 0 0	102 2 0	19 1 6	—	4 15 3	—	—	—	6.3	Rented
Edubia ...	Sept., 1930	11	5 17 0	73 15 6	7 14 5	—	2 3 9	—	—	—	4.5	Rented
Anyinam ...	Aug., 1930	11	9 19 0	96 2 8	8 6 6	—	1 13 11	—	—	—	6.5	Rented
	Total ...	235	484 13 0	2,974 0 6	184 18 7	—	82 9 9	—	—	—	199.0	

APPENDIX A.—*continued.*

Name of Society.	Date formed.	No. of Members.	Paid-up Capital. £ s. d.	Revenue from sale of cacao. £ s. d.	Expenditure. £ s. d.	Profit shewn at end of year. £ s. d.	Loss shewn at end of year. £ s. d.	Amount placed to Reserve Fund during year. £ s. d.	Total Reserve Fund. £ s. d.	Dividend paid. £ s. d.	Quantity of cacao sold. Tons.	Store owned or rented.
KUMASI AREA. (ASHANTI).												
Atasomanso ...	July, 1918	34	47 15 0	464 3 3	38 4 1	9 7 3	—	2 7 0	5 8 0	3 11 8	27.2	Owned
Pechi	July, 1918	64	83 10 0	1,122 18 0	36 9 8	33 8 8	—	8 8 0	13 1 0	6 5 3	70.1	Owned
Kokobin ...	July, 1918	40	51 10 0	238 6 8	13 8 0	5 0 11	—	1 6 0	2 18 0	3 14 11	18.5	Owned
Agona ...	May, 1929	21	36 16 0	237 13 7	37 16 10	—	2 7 0	—	2 1 0	—	12.8	Owned
Ankasi ...	May, 1929	38	36 5 0	560 18 8	22 12 8	15 19 9	—	4 0 0	7 10 0	6 9 4	32.5	Owned
Jamase ...	April, 1929	40	35 10 0	489 0 10	19 0 2	26 2 3	—	6 11 0	8 14 0	2 13 3	27.9	Owned
Asamang ...	May, 1929	30	50 13 0	524 19 2	9 8 4	18 19 9	—	4 15 0	5 17 0	3 16 0	30.7	Owned
Bipoa	July, 1929	26	23 1 0	355 8 4	33 18 2	18 9 1	—	4 13 0	10 8 0	1 14 7	21.0	Owned
Ntonsu ...	May, 1929	18	14 14 0	207 16 7	23 7 0	6 11 3	—	1 13 0	1 13 0	1 2 0	12.1	Owned
Afaminaso ...	May, 1930	22	9 16 0	184 18 4	28 4 2	12 8 2	—	3 2 0	3 2 0	0 15 0	10.4	Owned
Npobi ...	May, 1930	14	18 17 0	139 9 9	17 11 1	8 15 0	—	2 4 0	2 4 0	1 8 3	8.6	Owned
Akrofonso ...	May, 1930	15	19 13 0	196 1 9	23 12 9	6 0 1	—	1 10 0	1 10 0	1 9 5	11.0	Owned
Ampabame ...	May, 1931	10	11 18 0	—	0 7 9	2 9 10	—	0 12 0	0 12 0	0 17 7	—	Owned
	Total ...	372	439 18 0	4,721 14 11	304 0 8	163 12 0	2 7 0	41 1 0	64 18 0	33 17 3	282.8	
Grand Total for 41 Cacao Producers' Marketing Societies operating during 1930–1931.		949	1,217 3 0	9,892 13 0	632 11 5	281 2 9	98 11 9	65 1 1	91 1 91	51 0 6	619.2	—

APPENDIX A.—*continued.*

Name of Society.	Date formed.	No. of Members.	Paid-up Capital. £ s. d.	Revenue from sale of cacao. £ s. d.	Expenditure. £ s. d.	Profit shewn at end of year. £ s. d.	Loss shewn at end of year. £ s. d.	Amount placed to Reserve Fund during year. £ s. d.	Total Reserve Fund. £ s. d.	Dividend paid. £ s. d.	Quantity of cacao sold. Tons.	Store owned or rented.
RICE SOCIETY. APPOLONIA AREA (WESTERN PROVINCE).												
Esiama ...	Nov., 1928	35	99 15 0	33 9 9*	45 16 1	5 9 7	—	—	—	—	—	—
THRIFT AND LOAN SOCIETIES.												
Department of Agriculture.	Feb., 1928	68	174 17 0	161 9 7†	6 9 0	21 19 2	—	4 3 0	14 8 11	12 7 5	—	—
Agriculture and Forestry Training Centre.	July, 1929	76	80 2 0	—	39 13 8	4 16 10	—	1 4 2	1 4 2	3 12 8	—	
Grand Total for 44 Societies operating during 1930–31		1,128	1,571 17 0	10,087 12 4	724 10 2	313 8 4	89 11 3	70 17 3	108 4 2	67 0 7	619.2	—

*Sale of Rice.
†Sale of Provisions.

APPENDIX B.

District.	Name of Society.	Date formed.	No. of members.	Capital subscribed £ s. d.
EASTERN PROVINCE.				
Volta River	Peki Blengo ...	February 1931	16	3 18 0
	Todome	March 1931	16	2 8 0
	Wudome	March 1931	19	2 1 0
	Jakai	March 1931	10	0 12 0
	Tsito	March 1931	12	1 4 0
	Peki Tsame ...	March 1931	8	0 9 0
	Adjakoe	March 1931	19	1 13 0
	Kpalime Toh ...	April 1931	21	1 17 0
	Tonkor	April 1931	10	0 10 0
	Kayera	April 1931	10	0 10 0
Total	10		141	15 2 0
North Birim	Maasi	March 1931	10	3 17 0
	Anyinam	March 1931	10	2 10 0
	Begoro	March 1931	11	2 15 0
	Old Tafo	March 1931	10	2 10 0
	Anyinasin ...	March 1931	13	3 5 0
	Kibi	March 1931	17	5 4 0
	Kwabeng	April 1931	11	2 15 0
Total	7		82	22 16 0
South Birim and Nsawam	Adumadum ...		27	6 15 0
	Asamankese ...		16	—
	Adeiso		12	—
Total	3		55	6 15 0
Akwapim ...	Pakro	April 1931	35	7 5 0
	Akropong	April 1931	43	3 12 0
	Amanokrom ...	April 1931	11	1 1 0
	Mangoase Shai ...	April 1931	10	0 10 0
Total	4		99	12 8 0
CENTRAL PROVINCE.				
Cape Coast ...	Mansu	April 1931	10	2 0 0
Total	1		10	2 0 0
WESTERN PROVINCE.				
Sefwi	Anwiaso	April 1931	33	—
	Kojina	April 1931	13	—
	Perasso	April 1931	10	—
	Adukrom	April 1931	14	—
	Patabosso	April 1931	18	—
Total	5		88	

APPENDIX B.—*continued.*

District.	Name of Society.	Date formed.	No. of members.	Capital subscribed.
EASTERN PROVINCE ASHANTI.				
ASHANTI AKIM ...				
	Juaso	February 1931	18	2 11 0
	Adomfi	February 1931	14	1 19 0
	Bompata	February 1931	14	1 17 0
	Wenchi	February 1931	15	2 1 0
	Mawso	February 1931	17	1 13 0
	Obogu	February 1931	12	1 11 0
	Amantra	February 1931	10	2 4 0
	Atwidie	February 1931	15	1 14 0
	Wiosu	February 1931	13	1 14 0
	Nkwanta	March 1931	14	3 0 0
	Odumase	March 1931	20	1 0 0
	Obenemasi ...	March 1931	13	1 5 0
	Chichibiase... ...	March 1931	14	0 14 0
	Agogo	April 1931	15	4 4 0
	Domiabra	April 1931	10	1 14 0
Total	15		214	29 1 0
EASTERN PROVINCE ASHANTI.				
Kumasi and Mampong	Ejuratia	April 1931	15	—
	Dome	April 1931	14	1 19 0
	Kassaam ...	April 1931	12	3 0 0
	Safo	April 1931	10	2 1 0
	Kona	April 1931	17	2 15 0
	Buonim	April 1931	20	3 2 0
	Aminasè	April 1931	10	2 2 0
	Wiamuase	April 1931	30	1 18 0
	Yonsu	April 1931	8	—
	Chichiwere	April 1931	8	—
Total	10		144	16 17 0
Bekwai	Denjiase	April 1931	17	8 10 0
	Boni	April 1931	12	—
	Poano	April 1931	16	3 0 0
	Atwere	March 1931	12	1 5 0
	Mansu Nkwanta ...	April 1931	18	3 5 0
	Mim	April 1931	9	0 10 0
	Sintrisu	April 1931	12	—
	Ajajukrom	April 1931	9	—
	Abori	April 1931	20	0 13 0
	Ankam	April 1931	13	—
	Abenchin	April 1931	10	—
	Abodom	April 1931	12	3 0 0
	Asokore	April 1931	11	2 15 0
	Dotum	April 1931	10	2 10 0
	Abuoso	April 1931	8	2 0 0
	Edwinase	April 1931	15	3 15 0
	Nsiano	April 1931	11	—
Total	17		215	31 3 0
Grand Total ...	72		1,048	136 2 0

APPENDIX C.

QUANTITY OF CACAO BROUGHT TO SOCIETIES BY MEMBERS.
(IN LOADS AND LBS.)

Quantity in loads of 60 lbs.	Number of Members in each class.				
	Bisa Area.	Oda Area.	Kumasi Area.	Nsawam Area.	Peki Area.
No Cacao	65	36	44	35	2
0– 5	25	5	13	2	2
5–10	50	17	38	2	1
10–15	21	25	53	6	2
15–20	16	23	36	1	2
20–25	20	29	30	2	2
25–30	12	19	36	2	2
30–35	8	17	21	—	2
35–40	4	12	21	1	1
40–45	5	11	15	—	2
45–50	4	8	7	—	—
50–55	7	6	8	—	1
55–60	2	2	9	1	1
60–65	3	5	5	1	2
65–70		1	11		
70–75	1	6	2	—	1
75–80		3	1	—	
80–85	—	2	4	—	—
85–90	—	1	2	—	—
90–95	—	3	3	—	1
95–100	—	1	1	—	
Over 100	4	8	12	—	—
Totals ...	247	240	372	53	24
Average quantity of cacao brought in by all members ...	16 lds. 1 lb.	31 loads	28 lds. 23 lb.	7 loads	33 lds. 20 lb.
Average quantity per member (excluding those who brought no cacao) ...	21 lds. 44 lb.	36 loads	32 ld. 12 lbs.	24 loads	36 lds. 24 lb.

PAPER No. IV.

THE CO-OPERATIVE MOVEMENT IN NORTH BIRIM.

By Captain V. W. BRATTON.

(*Capt. V. W. Bratton, seconded temporarily from the Political Administrative Service.*)

FOREWORD.

In January 1930, the writer was seconded to the Department of Agriculture for duty in connection with the formation of " Cacao Producers' Co-operative Societies."

Needless to say the writer's knowledge of such work was of the slightest but this was soon remedied by a short but intensive course of instruction which consisted of lectures delivered by the Honourable Director of Agriculture and members of the Headquarter Staff of the Department of Agriculture.

AREA OF OPERATION.

On the conclusion of the course the writer was posted to North Birim District, his headquarters being New Tafo.

North Birim District lies in the State of Akim Abuakwa, the Omanhene (Paramount Chief) being Nana Sir Ofori Atta K.B.E. who resides at Kibi.

The State of Akim Abuakwa forms the Political District of Birim (Akim Abuakwa) under the administration of Captain J C. Warrington, District Commissioner, whose headquarters are at Kibi.

ORGANIZATION OF DISTRICT.

Shortly after arrival in the district the writer proceeded to get in touch with the District Commissioner and Omanhene with a view to the organization of the district in connection with propaganda work and it was decided at this meeting that the first step to be taken should be that of placing the matter before the Okyeman (State Council).

Two days later the Okyeman assembled with the Omanhene as President. The District Commissioner very kindly paved the way with a short well-chosen address at the conclusion of which the writer then addressed the Okyeman and endeavoured to the best of his ability to explain " Co-operation " and the benefits

arising therefrom. The members of the Okyeman having listened with interest asked at the conclusion of the address that time should be given for the consideration of the matter and requested that another meeting should be held when the members of the Okyeman could discuss the matter further and at the same time bring up any points on which they were not quite clear.

A further meeting was arranged and this proved to be a most interesting one. Member after member of the Okyeman rose and in some cases asked several questions including many knotty ones. Owing to the foresight with which the proposed draft "Ordinance for the regulating of Co-operative Societies" had been compiled and the knowledge gained during the course of instruction, the writer was in every case enabled to give a satisfactory answer. After these matters had been settled to the satisfaction of the Okyeman, the members of this body then gave their decision that in their opinion, the formation of co-operative societies would be beneficial to the farmers of the district and that the people should be so informed through their Chiefs and Headmen.

This favourable decision relieved the mind of the writer of a certain amount of anxiety as it meant that the holding of meetings in the towns and villages throughout the district was now possible and that these meetings would be attended by the elders and people who would listen and pay attention to anything that would be said concerning a matter which the Okyeman had approved. If on the other hand, the Okyeman had disapproved of the formation of societies then it would have meant that not only would the movement have lost the support of the administrative members of the State but it would also have been impossible to hold meetings as few, if any, people would listen to what had been disapproved of by their Okyeman.

So much having been attained, the next step was the selection of the first group of towns where meetings would he held. This at first sight would appear to be a task of no considerable difficulty. Unfortunately this was not so as it was extremely necessary to consider the following points :—

1. Which towns would give the quickest result.
2. Eliminating as far as possible towns in which failure would be met with.
3. Grouping of towns so that, say, three, could be visited on one day at the least possible expense.
4. Visiting of towns on those days on which the farmers were not at work on their farms.
5. Avoidance of towns in which there were faction disputes.

It can therefore be seen that selection of towns under such conditions was no easy task and much more so when one is strange to a district. With the aid of Captain Warrington, District Commissioner, a certain number of towns were chosen and it then remained to group them satisfactorily under points 3 and 4.—Point 4 proved to be practically impossible to eliminate as the " off day " for the farmers throughout the district was Friday. In view of this it was decided to wait and see the result of the first meetings and then arrange as far as possible for the most promising towns to be visited on Fridays.

The next step in the organization of the district was the notifying of Chiefs and Headmen of the towns selected giving them the date and time for proposed meetings at their towns. In this the writer was considerably helped by the Omanhene who very kindly sent out special letters to those concerned. Eventually all arrangements for meetings were completed and on the 2nd February the meetings commenced.

MEETINGS.

To deal with the meetings separately would involve a considerable amount of time and space and at the same time such a procedure would necessitate the inclusion of a certain amount of unnecessary detail. Therefore, it is deemed advisable to deal only with outstanding points and describe the attitude of the people and the difficulties encountered.

ATTITUDE OF THE PEOPLE.

The attitude of the people towards the movement for formation of co-operative societies was found to be one made up of the following elements : laziness, doubt and fear.

That of laziness, being natural, needs little if any comment except that in as far as the Gold Coast farmer is concerned with the production and disposal of his cacao crop it has been considerably helped along by two factors, the first of which is that up to date, the production and preparation of cacao has needed little physical exertion on the part of the farmer— labourers on the share system doing the little manual work required while the climate does the rest. The other factor is the cacao-buying system obtaining throughout the Colony whereby there is no necessity for the farmer to seek a market for his cacao as all that is required of him is to sit down in his village and await the arrival of the brokers kindly sent out by the merchants to purchase his cacao. Under this happy

system, the inherent laziness of the farmer has flourished only too well, with the result that, even in these times of financial depression he seems unable to shake himself free and realize that it is only by his own efforts will he once again obtain a fair price for his cacao.

The element of doubt needs more description and is due to several reasons: (1) that no definite promise can be given to the farmer that co-operation will result in a better price, (2) that in the past in this district many private co-operative societies were formed and in practically nearly every case these societies resulted in a loss to the farmer, and (3) an idea that these societies were in some way connected with the Federation.

The first requires no explanation as it can be clearly understood that no Government Officer could give an answer to the question "If we form these societies what will be the price of cacao?" beyond that answer of "One trusts it will mean an improvement but to what extent one cannot say". Such an answer and the only possible one does not satisfy the farmer (would it satisfy a farmer in any country?) and he consequently fails to see the benefit of forming a society which will not bring or promise a definite price.

The second is one that the farmer has every right to feel bitter about and he has very good reason to do so. In the past and one may also say the present this district amongst others has seen the formation of many associations organized by people not with any idea of benefiting the farmer but mainly with the idea of benefiting the organizer. Not only did natives of the Gold Coast organize these societies but also certain Europeans. In every case the bait was the same—that of the better price the farmer would obtain if he could allow the organizer to take the cacao on part-payment the balance of the price being paid after the cacao was shipped or sold. Farmers in town after town swallowed the alluring bait of the high price the organizer held out, 25s. a load, 30s. a load, 33s. a load, and in every case farmers parted with their cacao on moderate part-payments, and in every case the farmers are still "watching and waiting" for the return of the organizer with the balance. Is it any wonder, then that the farmers fight shy of societies? It is now so firmly fixed in their minds that societies result in a loss to them that it is practically impossible to get them to eliminate this idea from their minds and they even think in some cases that the Government is now out to benefit at their expense.

The third reason—the idea that these societies were in some way connected with the late Federation—is one for which it is practically impossible to give an explanation except that the propaganda work in this district followed so closely on the heels of the activities of the Federation that the two became linked together in the farmer's mind. However this idea was quickly explained away. The element of fear springs from the following:—

1. Possible taxation by Government on the purity of cacao produced.
2. Interference by the Government in the sale of cacao.
3. Possibility of being ordered to centralize their cacao in towns outside their own towns and villages.

With regard to the first point: For some mysterious reason or other the farmer in the Gold Coast always regards any new move by the Government as part of a scheme which will eventually result in some form of taxation. The formation of co-operative societies by Government was to the farmer in this district a completely new idea. Although co-operative societies have been working successfully in Ashanti and other parts of the Colony for some time past the great majority of the farmers here had never even heard of these societies and as usual the farmers immediately jumped to the conclusion that their formation was a cunning move on part of the Government to get to know the amount of cacao grown by them in order to lay a tax thereon. This idea was well fostered by the brokers in their anti-co-operative society propaganda and has proved one of the great stumbling blocks in the formation of societies. Even in the minds of farmers who have become members of societies. the idea still persists but on the principle that two can play at a deep game, the half-convinced farmer has decided to test these societies to the extent of selling half his cacao—the remaining half being sold independently. This of course may be contrary to the rules laid down for societies but in the interest of all concerned and to foster the movement at first, such an arrangement must be overlooked, as it will be only by experience that the farmer will see that he has no grounds for such fear.

The second: "Interference by the Government with the farmer in the sale of his cacao": Brokers in their anti-propaganda spread this idea throughout the country and backed it up by pointing out that the Government had decided to use these societies as means to prevent the farmers holding up their cacao as they had done in the days of the Federation. The farmer having had his experience of listening to the prophets of the Federation who advised him when to sell and when not to—does not want any more advice, or interference with his own wishes. Consequently when he heard from the brokers that the Government was now going to decide by means of these societies when he should sell or not, he naturally decided to give them a wide berth. No explanation or promise would convince the farmers, and, consequently once again, they must be allowed to "wait and see" that no such interference will at any time occur.

The third: "Possibility of centralization outside their own towns": The majority of the farmers were filled with the idea that they would be ordered to centralize their cacao in one or two

large towns in the district—a scheme utterly abhorrent to them. Where this idea came from it is impossible to say—it certainly did not form part of the brokers anti-propaganda. Such a thing had happened in one or two areas with the usual result—loss to the farmers. The farmer has at long last decided not to allow the cacao out of his sight until payment has been made. This fear was quickly put an end to by issuing a signed letter from the Director of Agriculture in which the Director definitely promised that no cacao belonging to societies would be allowed to be removed until payment had been effected.

From the above it will be seen that the attitude of the people towards co-operative societies was such that it might be described as the greatest difficulty one had to encounter. It was, of course, impossible to remove the first element referred to—laziness. As long as the farmer remains in his simple state and blessed with a country and climate which keeps him from starvation it will never be removed. The remaining elements—doubt and fear—cannot be removed at first and will not be eliminated until the societies have proved themselves to the farmer, who can then see that there is no ground for these doubts and fears.

DIFFICULTIES ENCOUNTERED.

The difficulties encountered were many and various. Compared, however, with the obstacle presented by the attitude of the people, they were in the great majority of a minor character and easily overcome.

The difficulties encountered were as follows :—

1. Obtaining of meetings,
2. Brokers' anti-propaganda work,
3. Previous private associations,
4. Elders refusing to give a lead,
5. Fear of taxation by the Government,
6. Financial difficulties,
7. Point-blank refusal to form societies.

The first, that of obtaining meetings, was due to the fact that it is the usual custom for meetings in towns and villages to be obtained through the Chief or Headman. It is therefore necessary to ask the Chief or Headman to notify his people of the proposed meeting and should he fail to do so, no meetings can be obtained. In the case of the first one or two meetings, the Chief and Headmen carried out their duty and consequently some idea of these societies reached the people. After these meetings, in several cases, the Chiefs and Headmen either from animosity to the move-

ment or indifference, failed to notify their people, with the result that on several occasions in different towns no meetings could be obtained. The fact that the Chiefs and Headmen failed to notify their people made the position of affairs somewhat delicate. In some cases the Chiefs and Headmen became extremely annoyed when an attempt was made to obtain meetings through influential people residing in their town, and they let it be known that people attending these meetings would be looked upon with disapproval. As a result of this attitude matters came to a standstill. Fortunately, this position of affairs came to the ears of the Omanhene (a warm supporter of the movement) and he pointed out to the Chiefs and Headmen concerned that such a course was extremely unwise on their part and that in the interests of their people they should be notified of these meetings, pointing out at the same time that attendance was voluntary and that any one who wished to join these societies could do so without interference. It was entirely due to the Omanhene's intervention and good advice that this difficulty was overcome ; and although the attendance at meetings dropped considerably and many Chiefs and Headmen refused to have anything to do with the movement, the Omanhene's warm support made it possible for the officers concerned to visit the towns and get in touch with the people interested.

The second, " Brokers' anti-propaganda work " : Brokers realizing that the formation of these societies would eventually do away with their occupation, rapidly banded themselves together and started an Anti-Society Campaign. They spread the wildest rumours—" Government taxation of the cacao produced by farmers "—" Government control of the sale of cacao, " etc., etc." This difficulty was overcome by the posting in towns for two or three days of experienced overseers who got in touch with the people and quickly refuted these rumours. At the same time whenever officers held meetings and found brokers in attendance they made a point of asking these brokers for questions. Naturally they were somewhat shy in complying with this request and in the great majority of cases refused. At some meetings the people attending insisted on their doing so. On their refusal the people usually passed somewhat sarcastic remarks which ended in the retirement of the brokers concerned—very much discomfited.

The third, " Previous private associations" : This has been dealt with to some extent under " The attitude of the people " and does not require much more explanation here. The fact however remains that owing to the impression left by these private associations, not only on the minds but also on the pockets of the farmers, the great majority of the farmers now view with distrust any kind of society. However when it was learnt that Government officers were supervising these societies and that the Government would be responsible for any money subscribed by them, a certain number of farmers came forward. The great majority, however, refuse to

have anything to do with co-operative societies and only time will show them the advantages thereof. It is, however, but just to say that farmers are gradually losing their suspicions and wherever societies have been formed new members come forward at every meeting. This difficulty will not be entirely overcome until farmers prove or see for themselves that their fears are groundless.

The fourth, "Elders refusing to give a lead": That this should be a difficulty may seem somewhat extraordinary to anyone who is not acquainted with the customs of people of the Gold Coast in their villages. It must however be remembered that all affairs and matters relating to the welfare of a town or village community are in the hands of a body of elders who, in fact, govern the people of the town. All the inhabitants with very few exceptions follow the lead of the elders and those who do not, speedily become unpopular. It can therefore be seen that any matter which meets with the disapproval of the elders meets with the disapproval of the people. In a number of towns the elders refused to have anything to do with co-operative societies—some because they belonged to the Akan Farmers Association and did not wish to become members of the new societies; others because they were antagonistic having listened to and acted upon the advice of a broker relative. When the elders refused to become members no one would come forward and join. Meetings in certain towns after definite refusals from the elders had to be abandoned. These towns must now of course be left until the elders realize their mistake and ask for a Government Officer to come and form a society. Fortunately such towns were not many and their places on the lists were quickly filled by towns whose people were anxious for meetings.

The fifth, "Fear of taxation by the Government": This has also been dealt with under "The attitude of the people" and this difficulty therefore requires no further explanation.

The sixth, "Financial difficulties": Owing to the low prices ruling during the cacao season last year, many farmers found themselves in debt and were unable to find the money necessary to become members of societies. This of course was a difficulty that could not be overcome at that time and these farmers had to be content to wait until they had sold part of their mid-season crop.

The seventh: "A point-blank refusal to form a society," was the greatest difficulty of all and left officers employed in the formation of societies baffled. After several meetings, when the time came for the people to give a decision, the decision would be "We do not want a society." No explanation would be forthcoming, and questions as to why they refused would be met with the same answer. Overseers would be posted to these towns in an endeavour to find out the reasons of refusal but there was always a negative result. Consequently the only thing the officers concerned could do was to withdraw and abandon the town to its fate, as it was

found to be a waste of time to hold further meetings in such towns. It can therefore be seen that the formation of co-operative societies in North Birim was no mean task. It is, however, gratifying to state that success has been met with and a number of societies formed, while promises have been received from many towns that societies will be formed in the very near future.

FUTURE POLICY.

Although a number of societies have been formed they are still in their infancy and many people doubt their success. The main season crop will shortly be put on the market and it will be during this time that the societies should prove their worth not only to the members concerned, but also to outsiders. It is therefore advisable that the societies should be extraordinarily well nursed and, at present, that only a number capable of exact supervision be formed. Innumerable demands and, oft-times, foolish ones will be made on the Officer-in-charge of these societies. He will find his hands full and should any society feel that they have a grievance unattended to, the members of that society will undoubtedly, without reference to any one, dissolve it. To justify the faith the new societies have put in the Government and to give the Officer-in-charge an opportunity to deal faithfully and fully with them the writer considers that not more than twenty societies should be formed at present and that these be grouped as closely as possible. Once having got these present societies running properly and giving every satisfaction it will then be found that every town in the district will demand to have a society formed. Again having got the present societies running properly these societies will more or less understand the work, and the responsibilities and demands on the Officer-in-charge will gradually lessen. He can then turn to the question of forming another group being secure in the knowledge that the foundations of the movement have been well and truly laid.

CONCLUSION.

In closing this article the writer would like to express his gratefulness to the Omanhene Nana Sir Ofori Atta, K.B.E., and the District Commissioner, Captain J. C. Warrington for their extremely valuable assistance given him while engaged in this work.

PAPER No. V.

THE CO-OPERATIVE MOVEMENT IN THE SEFWI DISTRICT.

By W. A. S. COLE and R. J. T. HOOKE.

(*Mr. W. A. S. Cole, seconded temporarily from the Political Administrative Service.*)

For co-operative propaganda, the Sefwi District divides itself naturally into three areas—Sefwi Anwhiaso, Sefwi Wiawso, and Sefwi Bekwai—each being a native state under its own Paramount Chief. Each state therefore has been dealt with as a separate entity.

Sefwi Anwhiaso.

In this state, 10 societies have been formed with a membership of 154 and very shortly a further five societies are expected. This will be sufficient to cover the entire state. The Omanhene has rendered great assistance in the formation of these societies and is a member and a strong supporter of the one at Anwhiaso.

The first thing to be done will be the consolidation of these societies, after which their activities can be extended to include the outlying villages so that every farmer can be included.

Although societies have been formed, there is a lack of confidence among the members. This is quite natural as confidence can only be obtained through experience. This factor, together with the scarcity of money, does not make it an easy matter to raise capital, but as soon as cacao sales can be advantageously effected this will be of more assistance than any propaganda.

Sefwi Wiawso.

Co-operative propaganda can show no material result in this state up to the present, although it must not be inferred from this that societies will not be formed. Owing to the unfavourable attitude of the Omanhene of Sefwi Wiawso it was not possible to begin work until the end of April. Then the area round Asafo was chosen as the best point at which to begin, because it was the head-quarters of an enlightened and important sub-Chief, who was likely to prove helpful, and also because it is at the head of the new Road 303 W, which taps the large cacao growing hinterland towards the Western Frontier. It is probable that societies will be formed in this area in the near future.

The farmer's outlook on cacao at the present time has been seriously affected owing to the abnormally low price obtained in the district during the last season. In some places along the motor road, the price dropped as low as 2s. 6d. and 3s. per load. A few years ago when the people were advised to grow coffee, a large area in Sefwi Wiawso was planted up, and now this crop has no market. The farmers are afraid that cacao will fail them in the same way that coffee has. In some cases they are talking of deserting their farms, and either digging for gold or seeking work elsewhere. All over the area, however, many farmers are anxious for instruction as to how their farms may be improved, and it is by helping them in this way that their support may be won and societies started.

Sefwi people are very much more backward than those of the Central and Eastern Province, owing to the fact that it is only recently that they have been brought into nearer contact with civilization by means of roads. The farmer is, rather naturally, unwilling to begin this new movement, but, once a start has been made with one society, the task should be easier.

Sefwi Bekwai.

Progress in this state has been practically nil. This is almost solely due to political circumstances. The stool owns no land at all and is the tenant of the three neighbouring Amanhin of Sefwi Wiawso, Sefwi Anwhiaso and Upper Wassaw. Because of this the Omanhin dare not decide on a course of action until it has been approved by these three Amanhin.

Propaganda was carried on for about three weeks until the Omanhin withdrew his permission. Since then he has given no definite answer, either "Yes" or "No." When the Omanhin sees his three landlords agreeing to the formation of societies, there would seem to be no reason at all why he should not do likewise

Communications.

The Sefwi District is served by three roads. The main road from Wiawso to Dunkwa serves a small part of the Sefwi Wiawso State, and the Sefwi Bekwai State. There are two feeders from this road, one from Diaso to Bibiani which serves the Sefwi Anwhiaso State; and one from Wiawso to Asafo, which serves the Sefwi Wiawso State towards the Western Frontier, as far as Asanyanso. More than half the district (that part near the Western Frontier) is rich in young cacao farms, and is, as yet, untapped by roads, the cacao from this area having to be head-loaded to the selling centres. The cost of this is the biggest problem the farmer has to face.

SCARCITY OF MONEY.

Because of the low price obtaining for cacao during this last season the farmer has very little money. In many cases he has sold his crop by forward contract and being unable to meet his

liabilities is hopelessly in debt. When, during co-operative propaganda, the entrance fee and the shilling share system are mentioned, the farmer is afraid that it is a new scheme for getting more money from him and he is very dubious about the movement. This is a serious difficulty to be surmounted as the natives find it hard to understand how money can be subscribed to a society and still belong to them. When the shilling entrance fee has been subscribed, share capital is a very long time in materialising. This is readily understandable as often the members cannot afford the extra money, but after a cacao season of practical working, matters should be very much easier.

POWER OF THE AMANHIN.

There is one fact which must be realized by any person who has any work to do in this district and that is that the Amanhin are a real force in the district. In such a scheme as the co-operative movement, it is absolutely necessary to gain the goodwill and consent of the Omanhin in whose state the work is to be done, before a start is made. If such consent is not obtained, any work done will be useless from the beginning as none of the people will help in any way, and the Omanhin in question will probably become antagonistic.

GENERAL.

The central marketing and railing centre of the district is Dunkwa which is in the Ancobra District, and is 50, 63, 63, and 80 miles from the local markets. As, except in one instance, the headquarters of the local agents of the buying firms are also at Dunkwa, it is very difficult for them to carry out adequate supervision, and the farmer is at the mercy of the African agent and broker. The ultimate object of the co-operative societies must be the foundation of a central selling station at Dunkwa ; the cacao will be kept continually on the move from the villages to this centre, thus offering a quick return to the farmer at the best obtainable price. The farmer in the past has been left too much at the mercy of the petty broker, and as soon as he realizes the advantages of selling direct to the buyer in big quantities, the co-operative movement will receive a tremendous impetus in this district.

PAPER No. VI.

THE CO-OPERATIVE MOVEMENT IN TRANS-VOLTA (WITH NOTES ON LOCAL AGRICULTURAL ECONOMICS IN SOUTHERN TOGOLAND).

By H. S. STOVOLD.

(*Mr. H. S. Stovold, seconded temporarily from the Political Administrative Service.*)

Prior to the effort to extend Cacao Producers' Co-operative Societies in the Peki area, one society at Peki Abanase* had been formed in May, 1929 by Captain G. C. Coull, and it was thought that this society would be suitable as a nucleus for a group of societies in this district, for the following reasons :—

(i) Peki is the centre of a large cacao-producing country : it is well served by main roads and has consequent easy transport facilities.

(ii) All cacao produced in this area is exported from Accra.

(iii) Peki is the town of the Paramount Chief, Fiaga Kwadjoavi Dei X, the majority of whose people are Eve-speaking and of one race (Guang† however, is spoken at Anum, Nkawkubio, Dodi, Nayo, Toseng and Asikuma. The total number of persons of this race as shewn by the 1931 Census is 1,724 out of a total for the Peki State of 21,222).

PEKI ABANASE CO-OPERATIVE SOCIETY.

This society has had a successful year's trading. During the past season, over 21 tons of produce were sold at 8s. per load, and £9 17s. further share capital was subscribed.

The Statutory Audit was conducted by Mr. W. R. Hudson, Inspector of Plants and Produce, on the 26th May, 1931 for the co-operative financial year 1930–31. The audited accounts show that the nett loss of £9 13s. 7d. for 1929–30 has been reduced to one of £1 18s. 11d. after an amount of £11 15s. 6d. had been written off for depreciation of cacao bags. At the 30th April, 1931 the loans outstanding amounted to £15 and cash in hand and at Bank totals £40 17s. 11d.

* Originally named Avetile (ave = forest, ati = tree, eli = there are) and still so referred to by the natives ; later, when stone-built houses were erected, it became known as Abanase.

† A vocabulary of this unwritten language is at present under compilation.

The 24 members of this society have subscribed £62 9s. share capital, a fact which indicates the comparative wealth of cacao farmers two years ago. It is almost unnecessary to add that had the Co-operative Societies' Ordinance (No. 4 of 1931) been passed five years ago, the work of propaganda and the formation of societies would have been simplicity itself compared with the task which is now being undertaken.

INSPECTION OF PRODUCE.

On the occasion of the Peki Abanase Co-operative Society selling over 21 tons of cacao to the Bremen Factory, Limited, Mr. L. J. Packham, Assistant Superintendent of Agriculture, Kpeve, inspected the produce in the society's store and on examination found it to be of 96.4 per cent purity. Approximately 80 bags had previously been rejected by the society, a fact which emphasizes necessity for strict scrutiny of all cacao brought in by members. In future it will be possible for the cacao belonging to all societies to be inspected from Kpeve, as Assistant Inspectors of Plants and Produce will be posted at convenient centres to supervise the working of each of the sub-groups of societies in this area. At present, there is no Government official acting in the capacity of Secretary of any society.

THE FRENCH CACAO CARD SYSTEM.

It was decided that any extension of the co-operative movement should be confined to the Peki State, i.e., within the boundaries of the Volta River District, as further north the French Card System is in operation and all cacao exported to French territory. Under this system, cacao grown in the British Mandated area of Togoland is exempted from the import tax imposed in France on cacao from all countries other than French Colonies. In consequence, the farmers in this area are able at the moment to obtain a slightly better price for their produce by selling it to French and German buyers for export to France via Palime and Lome than if they sold it for shipment to Accra. As the amount of cacao which can be exported is limited, only that produce which is accompanied by a card is accepted as having been grown in the Mandated Area.

With regard to the quality of cacao exported under the card system the assumption that the French and German buyers prefer slaty beans would appear to be unfounded. In truth, although the standard of quality demanded is very high, slaty beans are not regarded as such serious defects as weevilly, mouldy or germinated beans. This system has been in force since 1926 and is very efficiently organized from Lome. No produce is allowed to be exported unless it conforms to the required legal standards.

TRANSIT CARD SYSTEM.

Besides a system of compulsory inspection* a Transit Card System is also in operation under which cacao grown in British Togoland may be exported via French Togoland to any country other than France. During the 1930–31 season, cards for half a ton each were issued for a total of 27½ tons at the Assistant District Commissioner's Office, Ho. These cards can be signed by the Assistant District Commissioner, Registrar, or Bailiff, specimen signatures being kept by the French Preventive Stations. They are available at the Preventive Station on the day of issue only and have the driver's name, lorry number and place of origin of the cacao endorsed on the reverse side.

PROPAGANDA.

To further the co-operative movement in the Peki area, the Fiaga was first informed of the intentions of the Department in this connection. He at once expressed his agreement with the aims of the movement and his support has since proved very valuable. Purely as a gesture of goodwill, he became a member of the Peki Blengo Co-operative Society—a gracious act which greatly stimulated local interest. Later, I addressed a meeting of the State Council at which were present all the Chiefs and Headmen who acknowledged the Fiaga as Paramount, and expounded, shortly and simply, the formation and aims of Cacao Producers' Societies.

During the month of February, 1931, meetings of local cacao farmers were arranged on suitable days in all the large towns which comprise this State. Geographically these towns fall into three groups situated along the three principal roads running approximately N.E. through the district, namely :—

(i) Asikuma-Anyirawase-Kpeve Road (No. 101E).

(ii) Asikuma-Peki-Adjakoe Road (No. 120E).

(iii) Todome-Boso-Anum Road.

Nearly 500 tons of cacao were transported from the Tsito area, i.e. Road No. 101E. and crossed Senchi Ferry during the twelve months October, 1928, to September, 1929, compared with approximately 600 tons from Peki.† Tsito, however, is probably the bigger producing centre, and the above difference is explained by the fact that up to the present all cacao on the Todome-Boso-Anum Road has been bought by petty brokers who have resold it at Peki. It is hoped that as a consequence of the formation of co-operative societies at every town on this road, the cacao will in future be transported direct to Accra.

* For a complete account on this system as it affects other kinds of produce, *See* " System of Produce Inspection in force in French Togoland" : J. T. H. Stein, (Paper No. XIX, Year-Book 1929, Department of Agriculture.)

† " Agricultural Produce crossing Volta River at Senchi Ferry "—A. C. Miles, Paper No. XVII, Year-Book 1929.

RESULTS UP TO AND INCLUDING MAY, 1931.

As a result of numerous propaganda meetings 13 new societies were formed during the months of February, March, April and May, 1931, at Peki Blengo, Todome, Wudome, Jakai, Tsito, Peki Tsame, Adjakoe, Kpalime, Toh, Tonkor, Kayera, British Kpeve and Tsatei. At the time of writing other societies are in progress of formation at Bame Goviepe, Vegbe, Anum and Kwanta. The total membership of these new societies as at the 31st April, 1931 was 175 and the paid-up capital £20 14s.* Five of these societies were in possession of complete sets of books, duly written up, and the necessary By-laws. With the exception of Tonkor all the towns named are situated on the three roads previously mentioned; it only remains for the necessary culverts to be completed on the road to this town to link it with the Todome-Anum Road.

The map appended shows the position of towns in which co-operative societies have been formed, and those in which the formation of societies is likely to be accomplished at an early date.

That these successes were gained is due to the following reasons :—

(i) Staying for at least one night, sometimes even a week, in one village and mixing with the cacao farmers, perhaps visiting their farms. It was found that a visit lasting a few hours was invariably useless and probably did the movement more harm than good. Patience, pains and politeness were essential, firstly, to break down the natural mistrust in conservative minds of any thing new especially where the payment of money is necessary, and secondly, to gain the goodwill and confidence of the farmers.

(ii) The repeated assurance at every opportunity that the co-operative movement was non-political in its aims, and that Government understood how, up to the present, illiterate cacao farmers had been largely at the mercy of unscrupulous brokers.

(iii) The use of the most simple language and the avoidance of all statistics in addressing propaganda meetings. It is futile to discuss world economic problems with illiterate Africans who have never travelled more than a comparatively few miles from their own village and who have no knowledge of, and cannot comprehend, anything concerning the outside world.

(iv) The use of the vernacular whenever possible.

* *Vide* Table for detailed figures of each society.

DIFFICULTIES.

The principal difficulties met with fall under two heads, namely:—

(i) political, on the Asikuma-Anyirawase-Kpeve road ;

(ii) poverty, general throughout the State.

Firstly, with regard to native affairs, it should be borne in mind that the Peki State is only 80 years old and was formed by small but independent chiefs seeking the protection of the Fiaga against their common foe, the Akwamus.* The main source of difficulty was the Benkum wing, consisting of the towns of Tsibu, Tsito, Anyirawase, Kwanta, Avenui and Bame, which claims independence and does not acknowledge the Fiaga as Paramount. The Benkumhene (Fia of Anyirawase) has consistently opposed the co-operative movement, on the grounds that it is a Government proposition and because the Fiaga supports it. In this connection, the District Commissioner, Akuse, writes : " The attitude of the Benkumhene to the Paramount Stool remains as truculent as ever. Despite having lost his case in the Provincial Council and in the High Court, the Benkumhene still declares he is independent." However, after many attempts, a co-operative society was formed in Tsito in March, 1931, but up to the time of writing, no other society has been formed in the towns which serve him. It is possible that in the near future, Kwanta, Vegbe and Bame will be persuaded to follow the example set by Tsito.

Secondly, the general lack of money due to the low price of cacao in the 1930–31 season made the collection of share capital a matter of considerable difficulty. In a number of towns, the local cacao farmers had not been paid more than a fraction of the full price for their sales of cacao during the previous season. These considerations, together with the falling price of cotton and food crops, and the fact that during the month of March, 1931 the Fiaga instituted a tax on all his subjects to cover the expenses of his Togoland tour, meant that the average illiterate cacao farmer, who had previously always spent what money came into his hands, was still further impoverished. It should be added that an evident rival consideration was the fall in the price of palm wine to four gallons for 1s.

POSSIBILITIES OF EXTENSION OF THE CO-OPERATIVE MOVEMENT.

(A) Cacao.

(a) Visits were paid during April, 1931 to two further towns both of which export their cacao via Accra : Nudu in the Akwamu State, and Goviepe, one mile from Kpeve but within the boundary of British Togoland.

* *Vide* " Native States of the Gold Coast " I.—Peki :—compiled by C. W Welman, formerly Secretary for Native Affairs.

The cacao farmers in each town were willing to form co-operative societies, and the question as to whether there is not a moral obligation on the Department to form societies in towns where it is proved that a genuine desire for a society exists, is one which deserves immediate consideration.

(b) The chief cacao-growing areas in Southern Togoland are as follows :—

(i) The valleys between the Taviepe hills, i.e. Ho Hill Station to the Honuta range, and the Bame-Honuta Road. The country here is very fertile and at present under-cultivated.

(ii) Avetime, Kpoeta, Honuta and Kpedze Divisions.

(iii) East of the Taviepe Hills, i.e. Tohohoe, Tainagbe, Shia, Klave and Hoe Divisions.

(iv) Sokode and Abutia Divisions, i.e. east of the Abutia Hills.

The produce from the first three areas mentioned either comes eventually into Ho market or goes direct to Palime on the Card System. The cacao from area (iv) is head-loaded into Tsito and goes to Accra.

(c) The French Card System, previously explained, at present negatives the advance of the co-operative movement northwards into the southern portion of British Togoland. There is every indication, however, that the time cannot be long delayed before the small difference which now exists between the prices offered in Togoland and in the Peki area will disappear entirely and that, within the next few years, it will only be financially profitable for buyers in the Mandated Territory to export their produce via Accra.

(B) Cotton.

Cotton is grown in Southern Togoland in pure stands for the most part and is of short staple type. In recent years, the price has fallen from 9d. to 2½d. a kilo and it is now even lower. The result is that, at Adaklu last year's crop has not been sold except in very small quantities for purely local spinning and weaving into coarse cloth.

A wide field for the extension of the co-operative movement is offered in respect of this crop, but serious difficulties must be overcome. The fact that cotton cannot be sold in large quantities untreated implies the formation of secondary societies and the question is at present under consideration. From my personal investigations, it would appear possible to form a Cotton Producers,

Co-operative Society at Adaklu provided a suitable market could be found for the produce. This would entail ginning and baling before local merchants would purchase it at a remunerative price. A solution of this problem may well open a new chapter in the history of co-operation in this country.

(C) Food Crops.

Despite the fall in price of food crops in both the Trans-Volta area and Southern Togoland, increasing quantities are being grown, the fall in price here being out of proportion to the heavier fall in the price of cacao. Cacao farmers in many large numbers are so discouraged at the low price which they obtained for their main crop last season that they are turning their attentions to food crops, the general importance of which is increasing greatly with the opening up of new roads, a fact which is proved by figures shewing amounts of agricultural produce crossing Senchi Ferry*.

Yams, maize and cassava are the principal crops extensively grown and exported to Accra and Keta. In return, large quantities of fish and salt are imported from the littoral and lagoon areas.

The question of Food Crop Producers' Co-operative Societies must be considered separately. The circumstances under which these crops are cultivated and prepared, the vast number of producers and the normally small price obtainable in comparison with the cost of transport involved, constitute new difficulties that must be surmounted. The problem of a satisfactory marketing system, however, outweighs all other considerations, as the sale of food crops is the means whereby ready money is obtained by the native for current needs.

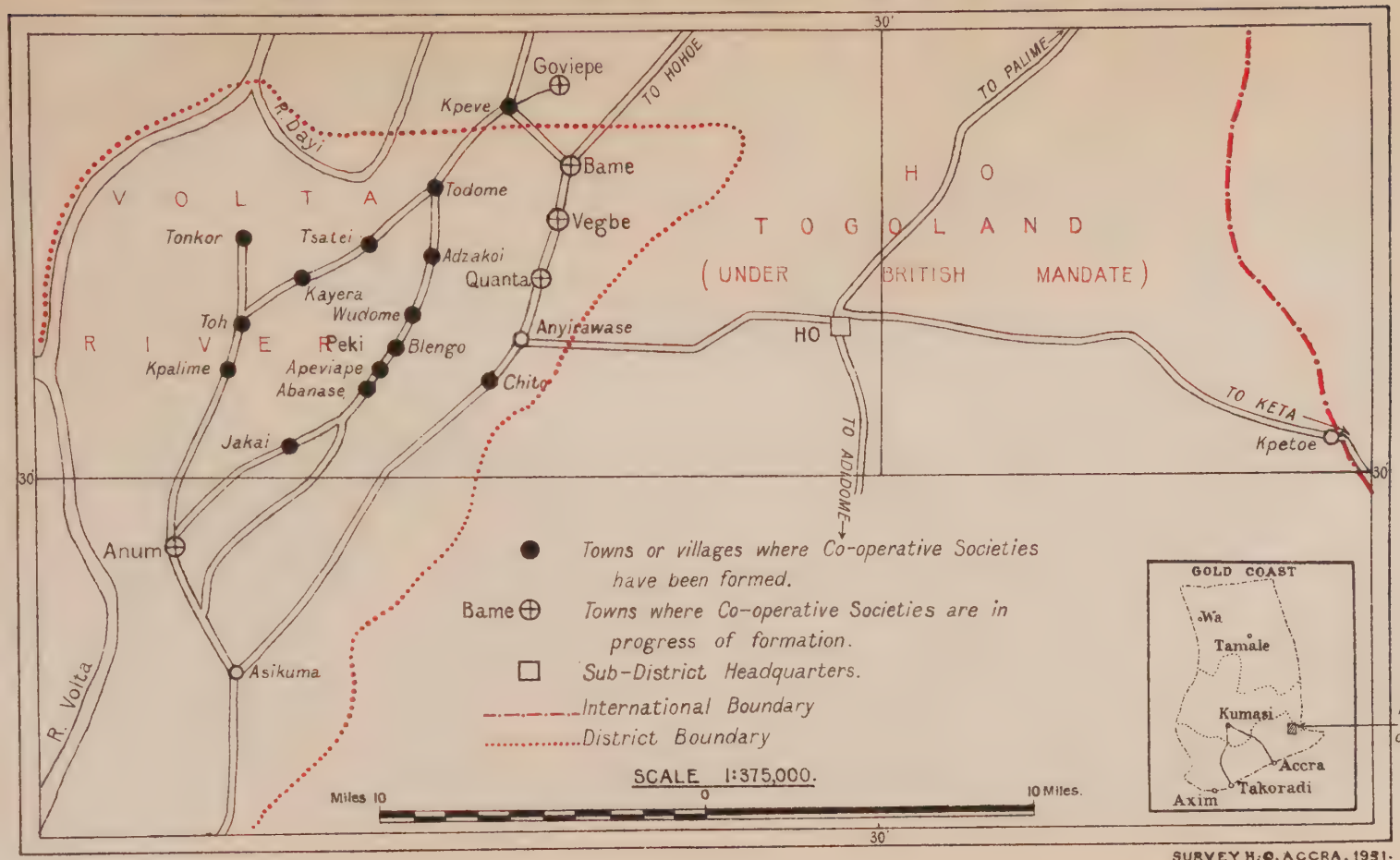
(D) Palm Oil.

Although the Trans-Volta area and Southern Togoland are not considered one of the main oil palm belts, considerable stands occur which form the basis of a small local industry.

The valley west of the Taviepe Hills is the principal producing area. Latterly there has been no demand for the oil at a price which the local producer considers sufficient to justify its preparation on a large scale. The position may, however, improve with the reduction of the import of gin. Development and organization are essential if a higher price is to be obtained from the merchants. Whether this product can be profitably incorporated within the co-operative movement requires further investigation.

* *Vide* Paper No. XVII by A. C. Miles, Year-Book, 1929, to which reference has previously been made.

MAP OF PEKI AREA SHOWING PROGRESS OF CO-OPERATIVE MOVEMENT.



SURVEY H.Q. ACCRA, 1931.

SUMMARY.

(i) The co-operative movement has already made considerable strides in the Trans-Volta area despite political hindrances and the general lack of money. Progress at first was slow but gradually confidence displaced mistrust.

(ii) The total membership of all Cacao Producers Co-operative Societies in the Peki State amounts to 199 with paid-up capital of £83 3s. 9d.

(iii) Propaganda work and the formation of new societies was confined to those towns which export their cacao via Accra. The life of the French Card System in operation in British Togoland is probably limited to a few years and the movement can then be extended northwards.

(iv) Both the Trans-Volta area and the Southern portion of the Mandated Territory are agriculturally favoured by having other peasant industries besides cacao. With careful fostering, these can be developed considerably to the financial benefit of the native.

TABLE OF RESULTS OF NEW SOCIETIES IN THE PEKI STATE UP TO AND INCLUDING THE MONTH OF MAY, 1931.

	Name of Society.	Date formed 1931.	Total population of Town Census, 1931.	Entrance Fees.	Share Capital.	Total paid as at 31st May, 1931.
					£ s. d.	£ s. d.
1	Peki Blengo	11th February	*Form B* 1,362	16	3 18 0	4 14 0
2	Todome ...	6th March ...	*Form A* 434	16	2 8 0	3 4 0
3	Wudome ...	8th March ...	508	19	2 1 0	3 0 0
4	Jakai ...	13th March ...	1,210	10	0 12 0	1 2 0
5	Tsito ...	20th March ...	1,896	12	1 4 0	1 16 0
6	Peki Tsame	27th March ...	626	8	0 9 0	0 17 0
7	Adjakoe ...	27th March ...	584	20	2 4 0	3 4 0
8	Kpalime ...	13th April ...	733	11	1 6 0	1 17 0
9	Toh	13th April ...	391	11	1 17 0	2 8 0
10	Tonkor ...	15th April ...	375	11	0 17 0	1 8 0
11	Kayera ...	16th April ...	83	10	0 14 0	1 4 0
12	British Kpeve	3rd May ...	500	21	2 14 0	3 15 0
13	Tsatei ...	15th May ...	256	10	0 10 0	1 0 0
		Totals ...	8,958	175	£20 14 0	£29 9 0

The above total population figure of 8,958 plus Peki Abanase (Form A) 2,130 = 11,088 out of a total for the Peki State of 21,222 or 52.25 per cent.

PAPER No. VII.

THE CO-OPERATIVE MOVEMENT IN ASHANTI AKIM.

By D. N. WALKER.

(*Mr. D. N. Walker, seconded temporarily from the Political Administrative Service.*)

After one month of instruction in the co-operative movement at Accra, work was begun at Juaso at the beginning of February. It was decided to visit as many villages as possible in the Ashanti-Akim District in a short space of time, and, for this purpose, this rather unwieldy area was divided into three districts with Juaso, Agogo and Kumawu as the working centres.

In order to obtain the utmost amount of publicity as quickly as possible, the policy was to form societies with the minimum amount of capital which would be sufficient to meet the cost of the books, etc., and, once an opening had been made by the formation of societies on this basis, frequent meetings could be held and at each of these more capital could be subscribed. It was estimated that regular small contributions would amount to a useful sum by September. This was considered more advantageous than insisting on larger payments at the beginning, which might serve to prevent farmers from joining.

The idea also was to work from the small villages upwards rather than from the large villages downwards. It was hoped that the smaller villages would receive the idea more readily than the larger, owing to the absence of obviously biassed opinions.

The first society was started on 5th February 1931 at Juaso. There was a membership of twelve and as the policy was one of publicity until the movement had gained popularity, one 1s. share was accepted from each member. The people seemed prepared to give the new scheme a fair trial. At first, the farmers were naturally shy, but they soon gained confidence and are now going ahead steadily, if rather slowly.

One society having been started others followed in regular succession, and during February eight were formed at Juaso, Obogurme, Adomfi, Bompata, Amantra, Mawso, Wenchi and Wiawso. There was a total membership of 95 for these eight societies. In the month of March five further societies were started at Nkwanta, Atwidie, Chichibiasi, Obenemase and Odumase with a membership of 73, and at the beginning of April two others were started at

Agogo and Domiabra with a membership of 23. At Odumase the existing Cacao Producers Association was reorganized to form the co-operative society there. By this time farmers began to take an intelligent interest in the points raised at meetings and they put forward many pertinent questions.

When it is realized that in 12 weeks 15 societies were formed the wide publicity given to the movement in a short space of time will be readily appreciated. Whilst explaining the book-keeping and the general working of a society, appeals were always made for more capital. The work proceeded comparatively smoothly and was not unduly hindered by any outside influence.

The total membership of all the societies in this district at the end of May was 220 with a paid-up share capital of £31 17s. working out at 2s. 11d. per head.

On starting work in the Kumawu-Efiduasi area, it was decided to refrain from forming a society unless each member bought a minimum of 5s. share capital. After two or three weeks this method was found to be impracticable as there is very little money at present and it was decided to revert to the minimum share capital, viz. 1s. and regular monthly contributions.

Since this area is much richer in cacao than the Juaso area more opposition was felt from brokers, but this was met by the explanation that in future years the brokers would find other work under the co-operative method of selling cacao.

It was found that the farmers agree most heartily that the old method of buying and selling cacao is bad, but, there is a feeling that Government is now trying to obtain control of the industry. However, careful explanations, and an increased knowledge of the new movement, will remedy this.

A suggestion has been put forward by the farmers themselves that Government should train overseers for the societies, just as tribunal clerks are trained and that on the completion of their training, these overseers should be engaged by a group of societies and paid out of their funds. In this way the farmers would feel that the societies were actually their own business and apart from the Ordinance, not subject to Government dictation.

Mr. G. E. C. Wisdom, District Commissioner, who is a staunch supporter of co-operation, has been carrying on propaganda work for some time and has given valuable assistance by speaking to the people on the subject.

The societies in the Juaso-Konongo-Agogo area are naturally divided into two groups. The first, consisting of the eight societies in and around Juaso, is a compact group as, with the exception of Asankari and Krofa, every village of importance within a radius of 6½ miles has started a society. It is quite possible that when the

movement has been working for a season these two places will also form societies. The other group is composed of the remaining seven along the Konongo-Agogo Road, viz. Odumase, Obenemase, Chichibiase, Domiabra, Amantra, Wiawso and Agogo. This leaves only four places of importance still without societies Konongo, Patriensa, Juansa and Fwidiem, but two of these will probably accept co-operation next year. If necessary more societies could be formed in the immediate neighbourhood of Juaso, and the area South and South-West of Agogo extended under another Inspector, relieving the Juaso Officer of the present societies in the vicinity of Agogo.

Heavy debts incurred, either for funeral rites, litigation, or as is more usual, for various materials supplied by traders, will be hard obstacles to overcome in several cases. They have hindered the formation of societies, and are also a drag upon those already formed, as the members have not the requisite means wherewith to take up any large number of shares.

The merchants' buying organization, which includes the system of advancing money against the cacao still on the trees, will also hinder progress until such time as the members realize that thrift is their strength. There seems to be a definite scarcity of money in this district owing to the bad price of cacao prevailing at present, so that many of the people are looking to the societies to be of assistance to them. They seem to be keen on trying to improve the present state of affairs and are willing to give the co-operative movement a chance. They are also desirous of raising the standard of their cacao and many questions have been asked as to how this may be accomplished.

The smaller villages were found to be in proportion less in debt to brokers and merchants than the larger, presumably because of their lack of greater security.

The minor crop is a negligible quantity, only a small number of men with large farms harvest this crop, and even then it is held over till the next major crop. This should give a greater opportunity for the consolidation of the societies here, and give them a fair chance of being on a sound footing by the time the cacao season comes round.

Even though there has been some criticism of the draining and pruning work carried out here in 1925–1926 by the Department, the farmers have proved that they have every confidence in the Agricultural Officers by the way in which they have sought advice and help at practically every meeting.

Much of the coming cacao crop is already mortgaged against advances to brokers owing to the indebtedness of the farmers but by the following year when these debts are cleared many new members will be enrolled. Also there is no doubt that there are

cautious farmers holding back at the moment who, when the success of the movement is assured, will readily throw in their lot with others. This also applies to those farmers who combine the work of farmer and broker.

From a glance at the map it will be readily seen that all the villages in this area are well supplied with roads and these lead into the railway centres of Asankari, Juaso and Konongo (the latter being the most important at the present time), therefore the produce can be quickly moved to a railhead.

While writing on the question of roads one or two points have become obvious in connection with future development and consolidation of the present system. The policy of constructing roads for local purposes ought not to be framed without regard to the main development. The important thing is that effort should not be wasted in building a road which can never be more than a mere branch road, when equally good results can be obtained by building a road which will ultimately serve as a link in an important through trunk road connection, i.e. wherever a move which offers an immediate " tactical " advantage also helps towards a " strategical " objective, it should be taken in preference to a move which offers a " tactical " advantage alone. For this purpose a special party consisting of (a) Agricultural Officer (b) Political Officer and (c) Surveyor should make a detailed and careful inquiry for determining the area of land which would be suitable for road development.

If the villages Petrechi and Akuekrom, approximately 12 miles apart, were joined by road, this would enable a merchant to touch most of the Agona, Effiduasi and Juaso societies in a comparatively short space of time, and now that societies have been started on a line from Ejisu to Kumawu, there is a complete chain north of the railway, from Kumasi to Juaso.

The future of societies in this area would appear to be bright, if it can be judged by the present outlook of the people, who are interested and desirous of doing something to help themselves. It is well to remember, however, that progress in the section formed by Juaso, Bompata, Adomfi and Konongo will of necessity be restricted by the limited output as proved by Mr. A. C. Miles in his Paper No. VI in the 1929 Year-Book.

PAPER No. VIII.

CO-OPERATIVE SOCIETIES IN THE OBUASI-BEKWAI AREA.

By W. BRIAN-SMITH.

(*Mr. W. Brian-Smith seconded temporarily from the Political Administrative Service.*)

The results of extensive propaganda work in connection with the formation of Cacao Farmers' Co-operative Societies in the Obuasi Bekwai area have been satisfactory, and the ultimate effect of these societies is likely to be far-reaching. Given sufficient time in which to enable the movement to gain a firm foundation, Cacao Producers' Co-operative Societies should revolutionize the cacao industry in the area. Farmers, on the whole, have readily embraced the ideals and principles placed before them and in many instances have both welcomed and expressed appreciation of the endeavour on the part of Government to assist them at a time when the fortunes of the industry have fallen to a low ebb.

In addressing meetings of farmers, emphasis has been laid on the probable financial benefits to be obtained by the farmers by the elimination of the brokerage system through the medium of co-operative societies. Further, the possibility of improving the quality of cacao in this country and hence insuring the industry against unequal competition on the world's market has been explained. The dominating economic principles of supply and demand have been placed before the farmer and it is possible that he is now more enlightened and can appreciate in some measure the inevitable effect of world economics on the industry locally.

Propaganda was also directed to assist the appreciation of the possibilities which might be obtained in setting the industry on a sound financial basis, by farmers financing themselves and collecting sufficient capital of their own to abolish the pernicious customs of obtaining advances of cash for present needs against the next year's harvest, or, alternatively, of mortgaging farms to professional money-lenders or of borrowing money from the same class at exorbitant rates of interest.

It was considered that the best results could be obtained in the formation of societies if farmers were approached through the medium of their chiefs and hence work was directed towards interesting the Amanhene and principal chiefs in the movement. It was premised that to form societies in Head Chiefs' towns and

work them satisfactorily would be the surest form of propaganda, since society in Ashanti has not as yet become detribalised to any noticeable extent, and power both actual and persuasive is still vested in the Head Chief. To this end the work in this district has been directed.

Results have, in the main, been encouraging. A society was formed at the Head Chief's town of Denyaase and almost immediately two sub-Chiefs of Boni and Poano expressed their agreement with the movement and societies were formed in their towns.

The Omanhene of Mansu Nkwanta also concurred in the movement and societies were formed in his town and in those of several of his sub-Chiefs. Thus propaganda was continued until now there are 17 promising societies in the area with a total membership of 224 and paid-up share capital and entrance fees of £41 10s., figures which in themselves appear conclusive in proving the enthusiasm in, and the appreciation of, the movement. It is to be hoped that more societies will be formed in the near future, until the district consists of an extensive network of co-operative societies containing groups of farmers all working for their common good, the good of the industry and of the Gold Coast.

In the adjoining schedule a list of the societies in the Obuasi-Bekwai area is given showing the present numerical strength of each society and the amount of capital subscribed in entrance fees and shares.

BEKWAI-OBUASI.

Co-operative Marketing Societies.

Serial Number.	Name of Society.	Membership.	Entrance fees paid.	Shares paid.	Total.
					£ s. d.
370	Denyaase	17	17/-	170	9 7 0
371	Boni	12	12/-	—	0 12 0
372	Poano	25	16/-	60	3 16 0
373	Atwere	12	12/-	25	1 17 0
374	Mansu Nkwanta	18	18/-	65	4 3 0
375	Mim	9	1/-	10	0 11 0
	Sintresu	12	12/-	—	0 12 0
	Ajajukrom	9	9/-	—	0 9 0
	Abori	20	20/-	13	1 13 0
	Ankam	13	6/-	7	0 13 0
	Adodom	12	12/-	60	3 12 0
	Asokore	11	11/-	55	3 6 0
	Dotum	10	10/-	50	3 0 0
	Edwinasi	15	15/-	75	4 10 0
	Obuoso	8	8/-	40	2 8 0
	Abenchim	10	10/-	—	0 10 0
	Nsiana	11	11/-	—	0 11 0
	17 societies.	224 members.	£10 fees.	630 shares.	£41 10 0 subscribed.

PAPER No. IX.

DETERMINATION OF MOISTURE-CONTENT IN CACAO BEANS.

By A. N. de HEER.

The aim of this work is to find a short, practicable method of determining, with reasonable accuracy, the percentage of moisture present in cacao beans. This moisture-content has been found by many workers to be of great importance as affecting the keeping qualities of cacao (e.g. cacao moulds when its moisture content is more than 8.5 per cent). In view of this it has been considered essential that a determination of this factor should be included in the inspection work at the ports.

Two methods have been tried in determining the moisture-content of beans, namely, the oven-drying and the Brown Duval methods. For the purpose of the present work, the latter was found to be unsuitable because of its laboriousness and the relatively few samples that could be dealt with in a day. The oven-drying method has therefore been adopted.

DESCRIPTION OF METHODS USED.

Three main points had to be determined :—

(a) The minimum period of time for drying.

(b) Whether samples of beans should be whole or crushed.

(c) The weight of sample to be used.

In fixing the first point, the convenience of the worker must be taken into account ; thus the period should either be under six hours, to allow the determination to be completed in a working day, or it should be around twenty-four hours or some multiple of twenty-four hours. The period must be as short as possible so that the results can be given to the owner with the least possible delay

With a view to shortening the period of drying it was thought that, as crushed beans would probably give up their moisture more readily than whole beans, crushing of all samples might be advisable. Experiments were carried out to find the advantages and reliability of results obtained from crushed samples.

As regards the last point, size of sample, it is obvious that, with limited facilities for drying, small samples have a great advantage. Experiments were planned to determine the smallest suitable size of sample which gave reliable results.

Work therefore consisted in drying, in steam ovens at 100°C, samples of a series of weights of crushed beans, and whole beans, and in measuring the percentage loss in moisture at fixed points in the drying process. The points selected were at 3, 6, 24, 48 and 72 hours.

RESULTS OF DETERMINATION.

Results are shown in Tables I and II. Table I deals with crushed beans, Table II with whole beans.

Examination of Table I shows that loss of moisture in the crushed beans was more rapid in the smaller samples. At 24 hours the percentage loss of moisture was constant in all samples at approximately 97 ; drying was complete in 48 hours. As results, after three and six hours drying, varied considerably even within one size of sample these periods may be regarded as useless for the present purpose. Losses at 24 hours, as already stated, were fairly constant and in view of the necessity for quick results there would seem no justification for carrying the drying further.

Table II shows that drying was much slower in the case of whole beans ; the mean losses of moisture after three and six hours were 65.4 per cent and 89.5 per cent respectively with a great variation between samples. At 24 hours all samples showed a mean loss of 95.8 per cent with very little variation. Drying was complete at 72 hours. Obviously 72 hours is too long a period to wait for results and as losses at 24 hours are constant it is justifiable to calculate the moisture content of the sample from the formula $\frac{x \times 100}{95.8}$ where x is the percentage loss in weight of the sample at 24 hours. This determination is very simple, the only data required are the original weight of the sample and the weight after 24 hours in the steam oven at 100°C.

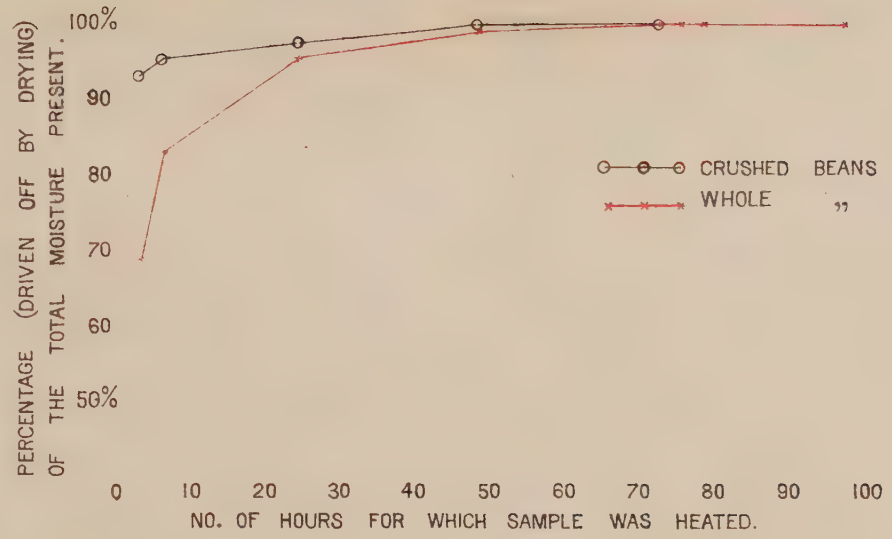
Regarding the size of the sample Table II shows that samples of 10 beans give the same results as much larger weights. As this is a convenient size to work with there is no object in taking larger quantities.

Mean results of experiments are shown on the graph opposite.

EFFECT OF CRUSHING.

Two samples were taken from each of a number of consignments of cacao. One sample was crushed and both were then placed in a drying oven and the moisture present in each determined. With samples containing approximately 8 per cent of moisture, the

RATE OF LOSS OF MOISTURE OF CACAO BEANS ON DRYING AT 100° C.



SURVEY H.Q. ACCRA, 1931.

determinations showed that there was .5 per cent less moisture in the crushed than in the whole beans. Thus about 6 per cent of the moisture present must be lost during the crushing process and, as these samples were crushed, weighed and put into the oven with as little loss of time as possible, it is obvious that much greater losses might occur when samples are being dealt with on a commercial scale.

SUMMARY OF RESULTS.

Twenty-four hours is the minimum suitable drying time necessary to make satisfactory determinations of the moisture-content of whole or crushed cacao beans. Shorter periods of drying give unreliable results and longer periods are not justified, owing to the necessity for immediate information. This period is convenient to the worker making the determinations.

Moisture is lost when beans are crushed. Samples of whole beans are more easily handled than crushed material. No time is saved by using crushed beans.

Samples of 10 beans give reliable results. This is a convenient size of sample with which to work.

CONCLUSIONS.

The percentage moisture present in cacao beans may be determined by drying a sample of 10 beans in a steam-oven at 100°C for 24 hours, finding the percentage loss in weight and multiplying this by $\frac{100}{95.8}$; or percentage moisture $= \frac{100}{95.8} \times$ percentage loss in weight after 24 hours drying at 100°C.

PAPER No. IX.

TABLE I.

LOSS OF MOISTURE FROM CACAO ON OVEN DRYING.

(Crushed Cacao.)

No. of Sample.	Moisture finally found to be present (per cent bean).	Rate of loss of moisture. (Calculated as percentage of total present.)				
		3 hours.	6 hours.	24 hours.	48 hours.	72 hours.
			5 grms.			
1	7.0	91.4	94.3	97.1	100	—
2	7.6	92.1	94.7	97.4	100	—
	Means ...	91.7	94.5	97.2	100	—
			10 grms.			
1	8.4	92.8	95.2	96.4	100	100
2	7.9	92.4	—	—	100	100
3	7.8	93.5	—	—	100	100
4	8.4	94.0	—	—	100	—
5	8.1	93.8	—	—	100	—
6	8.0	93.7	—	—	100	—
7	8.0	93.7	—	—	100	—
8	8.0	92.5	—	—	100	—
9	8.1	93.8	—	—	100	—
10	8.1	92.6	—	—	100	—
11	7.8	92.3	—	—	100	—
12	7.8	—	—	97.6	100	—
13	7.8	—	—	97.6	100	—
14	7.5	—	—	97.3	100	—
15	7.9	—	—	97.5	100	—
	Means ...	93.2	95.2	97.3	100	100
			20 grms.			
1	8.2	92.7	95.1	—	100	—
2	7.9	92.4	—	—	100	—
3	8.1	93.8	96.3	97.7	100	—
4	8.2	91.4	—	—	100	—
5	7.8	92.3	—	—	100	—
6	8.3	93.9	—	—	100	—
7	8.0	93.7	—	—	100	—
8	7.9	93.6	—		100	—
9	8.2	92.7	—		100	—
10	8.1	93.8	—	—	100	—
	Means ...	93.0	95.7	97.7	100	—

TABLE I—*continued.*

No. of Sample.	Moisture finally found to be present (per cent bean).	Rate of loss of moisture. (Calculated as percentage of total present).					
		3 hours.	6 hours.	24 hours.	48 hours.	72 hours.	75 hours.
				25 grms.			
1	8.3	94.0	95.2	97.5	100	100	—
2	7.5	90.6	—	—	100	100	—
3	8.1	93.2	—	—	100	—	—
4	8.4	92.8	—	—	100	—	—
5	8.0	93.7	—	—	100	—	—
6	8.0	93.7	—	—	100	—	—
7	8.4	92.8	—	—	100	—	—
8	8.2	92.7	—	—	100	—	—
9	8.4	92.8	—	—	100	—	—
10	8.4	92.8	—	—	100	—	—
	Means	92.9	95.2	97.5	100	—	—
				35 grms.			
1	7.4	91.9	94.6	100	100	—	—
2	8.8	92.0	94.3	98.9	100	—	—
	Means	91.9	94.4	99.4	100	—	—
				45 grms.			
1	8.0	90.0	92.5	100	100	—	—
2	8.6	90.8	93.0	100	100	—	—
	Means	90.4	92.7	100	100	—	—
				50 grms.			
1	8.4	88.1	94.0	97.6	—	100	100
2	8.2	86.1	92.7	97.5	—	100	100
3	8.0	85.0	93.7	—	—	100	—
4	8.3	88.7	92.8	96.4	100	100	—
5	8.2	89.0	—	—	100	100	—
6	7.7	92.2	—	—	100	100	—
7	8.4	90.5	—	—	100	100	—
8	8.1	86.4	—	—	100	100	—
9	8.2	89.0	—	—	100	100	—
10	8.2	87.8	—	—	100	100	—
11	8.3	87.9	—	—	100	100	—
	Means	88.3	93.3	97.1	100	100	100

TABLE II.

LOSS OF MOISTURE FROM CACAO ON OVEN-DRYING.

(Whole Beans.)

No. of Sample.	Moisture finally found to be present (per cent bean).	Rate of loss of moisture. (Calculated as percentages of total present.)					
		3 hours.	6 hours.	24 hours.	48 hours.	72 hours.	75 hours.
1	8.1	76.5	86.4	—	—	100	100
2	7.5	62.6	77.3	—	—	100	100
3	7.9	69.6	81.0	—	—	100	100
4	7.5	68.0	84.0	—	—	100	100
5	8.1	71.6	84.0	—	—	100	—
6	8.5	70.6	—	—	—	100	—
7	7.8	66.6	—	—	—	100	—
8	7.2	70.8	—	—	—	100	—
9	7.9	60.7	—	—	—	100	—
10	7.1	76.0	—	—	—	100	—
11	8.0	60.0	—	—	—	100	—
12	7.2	65.2	—	—	—	100	—
13	8.0	75.0	—	—	—	100	—
14	7.6	79.0	—	—	—	100	—
15	7.0	61.4	—	—	—	100	—
16	8.1	69.1	—	—	—	100	—
17	8.6	61.6	—	—	—	100	—
18	8.6	61.6	—	—	—	100	—
19	8.6	65.8	—	—	—	100	—
20	7.8	66.6	—	—	—	100	—
21	7.9	76.0	—	—	—	100	—
22	8.0	76.2	—	—	—	100	—
23	7.9	67.1	—	—	—	100	—
24	7.6	72.4	82.9	96.0	98.7	100	—
25	7.6	69.7	81.6	96.0	98.7	100	—
26	7.4	71.6	82.4	96.0	100	100	—
27	7.3	69.8	83.5	95.9	98.6	100	—
28	7.5	70.6	81.3	97.3	100	100	—
29	7.5	74.7	84.0	94.7	98.7	100	—
30	7.1	71.8	83.1	94.4	98.6	100	—
31	7.4	71.6	82.4	96.0	100	100	—
32	7.4	70.3	82.4	96.0	98.7	100	—
33	7.3	71.1	82.2	95.9	98.6	100	—
	Means	69.4	82.5	95.8	99.0	100	100

TABLE II—*continued.*

No. of Sample.	Moisture finally found to be present (per cent bean).	Rate of loss of moisture. (Calculated as percentage of total present.)						
		3 hours.	24 hours.	47 hours.	72 hours.	75 hours.	77 hours.	97 hours.
			20 grms.					
1	8.4	—	96.0	98.8	—	—	100	100
2	8.4	—	95.6	97.6	—	—	100	100
3	8.3	—	96.4	98.8	—	—	100	100
4	8.4	—	95.7	98.8	—	—	100	100
5	8.4	—	95.3	97.6	—	—	100	100
6	7.7	67.5	—	—	100	—	—	—
7	8.1	71.6	—	—	100	—	—	—
8	7.9	70.0	—	—	100	—	—	—
	Means	69.7	95.8	98.8	100	—	100	100
			50 grms.					
1	8.6	73.2	98.1	—	100	100	—	—
2	8.2	68.3	93.6	—	100	100	—	—
3	7.6	64.4	—	—	100	100	—	—
	Means	68.9	95.8	—	100	100	—	—

PAPER No. X.

ERRORS IN SAMPLING CACAO.

By H. B. WATERS.

The following notes have been prepared with the object of assisting those who are interested in the subject of sampling cacao. A short explanation of the theory of sampling has been supplemented by actual examples taken from the records of cacao inspection at Gold Coast ports, and the conclusions formed from this examination have been applied to devise methods of sampling suitable to local conditions and requirements.

The subject has been treated mainly from the mathematical view-point and numerous figures are the result, which, though they may deter some from reading this paper, will I hope convince those that do. To devise sampling methods without the aid of mathematics would be like laying bricks without a level. It would be equivalent to discarding the one tool by which judgment can be replaced by precision. For whereas experience may lead one to suppose that a certain sampling method is the best, mathematics can be used to appraise its merits and shortcomings exactly.

I am indebted to Mr. C. K. Haibo, Assistant Overseer in the Division of Statistics and Surveys, for working out the figures in most of the Tables in this paper. The distributions in Table III, the uniformity trials in Table VII, the calculations between bags and within bags (Tables VIII, IX, and X), and the error trials in Table XX, all bear testimony to his diligence and competence.

Inspection of cacao at ports.

Since January, 1927, all consignments of cacao leaving Gold Coast ports have been examined by the Department of Agriculture. From each consignment the Inspector has taken samples equal to the square root of the number of bags in the consignment, but never less than 20 samples. Each of these samples has consisted of 100 to 150 beans, of which 100 have been cut and examined for defects. Thus, an estimate of the mean percentage defects in a consignment of 1,600 bags has been obtained from 40 samples, each of 100 beans, taken at random from the consignment.

Sampling figures of a consignment.

The sampling figures for each consignment are recorded on a special sheet, as shown in the following example.

TABLE I.

Copy of Sampling Sheet used at Ports

Number.	2,497	Date Sampled.	13–11–29
Name.	Cadbury and Fry Ltd.	Date Shipped.	13–11–29
Marks.	Fry	Date Reported.	19–11–29
Size.	1,600 Bags. 100 Tons.	Ship.	M.V. Accra.
Samples.	40 Permit No. 77	Destination.	Liverpool.

	Weevilly but not Mouldy.	Mouldy.	Germinated.	Slaty.	Weevilly.	Defective.	Slaty.	All other defects.	Good.
Highest		5	6	9	0	7			
Lowest		0	0	0	0	0			
Average	0.0	0.6	0.4	1.9	0.0	1.1	1.9	2.0	96.1
No. of O's ...		24	31	10	40	17			
1	—	—	—	—	—	1	—	1	99
2	—	1	—	3	—	—	3	1	96
3	—	2	—	1	—	2	1	4	95
4	—	—	—	6	—	—	6	—	94
5	—	—	—	2	—	—	2	—	98
6	—	2	—	9	—	1	9	3	88
7	—	—	—	1	—	1	1	1	98
8	—	1	—	2	—	—	2	1	97
9	—	—	—	1	—	—	1	—	99
10	—	—	—	2	—	—	2	—	98
11	—	1	—	—	—	—	—	1	99
12	—	—	—	1	—	1	1	1	98
13	—	—	—	4	—	3	4	3	93
14	—	1	—	1	—	2	1	3	96
15	—	—	—	1	—	—	1	—	99
16	—	2	3	2	—	1	2	6	92
17	—	1	1	3	—	—	3	2	95
18	—	—	1	—	—	2	—	3	97
19	—	1	—	2	—	3	2	4	94
20	—	—	—	5	—	—	5	—	95
21	—	2	1	—	—	2	—	5	95
22	—	1	—	—	—	1	—	2	98
23	—	—	1	1	—	1	1	2	97
24	—	—	—	4	—	2	4	2	94
25	—	—	—	—	—	6	—	6	94
26	—	—	—	4	—	7	4	7	89
27	—	1	1	2	—	—	2	1	97
28	—	1	6	1	—	—	1	6	93
29	—	1	—	1	—	1	1	2	97
30	—	2	1	1	—	1	1	3	96
31	—	—	—	2	—	—	2	—	98
32	—	—	—	2	—	1	2	1	97
33	—	—	—	6	—	—	6	—	94
34	—	—	—	—	—	1	—	1	99
35	—	—	—	—	—	1	—	1	99
36	—	—	—	3	—	—	3	—	97
37	—	—	—	—	—	—	—	—	100
38	—	5	—	2	—	—	2	5	93
39	—	—	—	1	—	1	1	1	98
40	—	—	1	—	—	1	—	2	98
Totals	—	25	16	76	—	43	76	81	3,843

In Table I, the average or mean figures, obtained by dividing the totals by 40, show that 3.9 beans out of every 100 beans were defective and that 96.1 beans were good ; the mean purity of the samples was therefore 96.1 per cent.

Errors in sampling figures.

This figure, 96.1 per cent, is also the mean purity, as estimated from the samples analysed, of the consignment of 1,600 bags. The estimated mean purity may differ from the true mean, and the difference between the two is the error of the mean. The magnitude of this error depends on the following :—

Unavoidable sampling errors. These errors occur because sampling is dependent on the laws of chance.

Errors due to variability between bags. These errors arise because the contents of bags in the same consignment may differ markedly in quality.

Errors due to variability within bags. These errors arise because a single bag may contain cacao of different quality in different parts of the bag.

Avoidable sampling errors include personal errors, such as mistakes in addition, and mechanical errors, such as the use of sampling tools that give a bias to the result.

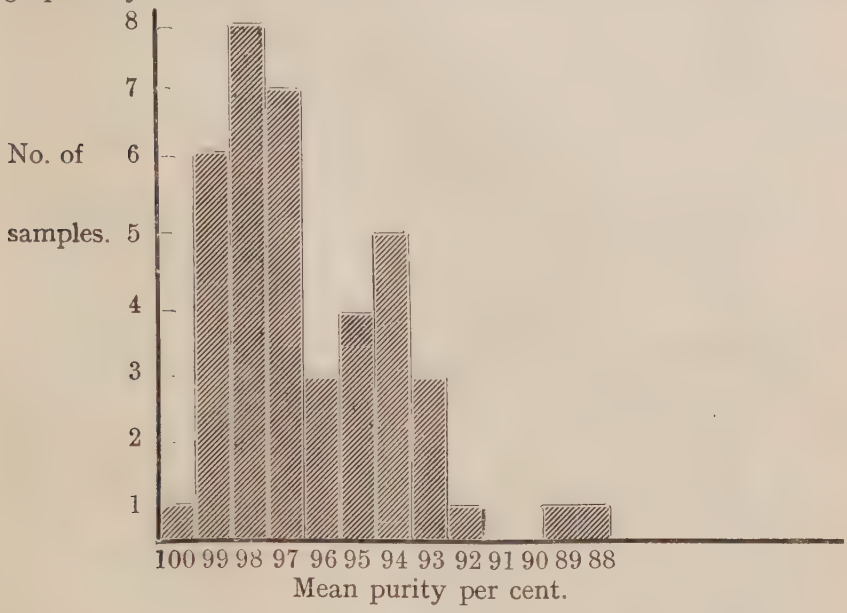
These four sources of error are explained and discussed in turn in later paragraphs.

Frequency distributions.

The last column on the right of Table I gives the purity of each sample. Examination of these figures shows that

		Per cent
1	sample had a purity of	... 100
6	samples had a purity of	... 99
8	samples had a purity of	... 98
7	samples had a purity of	... 97
3	samples had a purity of	... 96
4	samples had a purity of	... 95
5	samples had a purity of	... 94
3	samples had a purity of	... 93
1	sample had a purity of	... 92
1	sample had a purity of	... 89
and 1	sample had a purity of	... 88
Total 40	samples.	

Arranged in purity classes in this way, the 40 samples form a frequency distribution. This distribution may be recorded graphically as follows :—



From this distribution may be calculated the variability of the samples and also an estimate of the variability of the cacao in the consignment ; and from the variability may be calculated the error of the mean, i.e. the extent to which the mean purity of the samples is likely to differ from the true mean purity of the consignment.

Before discussing the subject of error, I propose first to deal with distribution and variability

DISTRIBUTION IN RANDOM SAMPLING.

The 95 per cent distribution.

When a single sample is taken from a heap of cacao beans that have been thoroughly mixed, the sample will not always give a true picture of the heap. If the heap contains cacao of a mean purity of 95 per cent, every sample of 100 beans taken at random from the heap will not always consist of 95 good beans and five defective beans. Some of the samples will contain 96 good beans, or 97, or more ; others will contain 94 beans, or 93, or less. The chances of drawing a sample containing any particular number of good beans can be worked out either by trial with a large number of samples, or by mathematics. Suppose that 1,000 samples are taken, then, on an average, the chances are that six of these 1,000 samples will consist of 100 good beans, 31 samples will contain 99 good beans, 81 samples will contain 98 good beans,

and so on. The expected number of samples in each purity-class is given in column 2 of the following table, the figures of which have been calculated by mathematics :—

TABLE II.

DISTRIBUTION OF SAMPLES FROM CACAO WHICH HAS BEEN THOROUGHLY MIXED AND WHICH HAS A MEAN PURITY OF 95 PER CENT.

1.	2.	3.
No. of good beans in 100 = Purity %	Expected no. of samples out of 1,000 (to nearest whole number.)	Odds against a single sample being of this purity.
100	6	166 to 1
99	31	31 to 1
98	81	11 to 1
97	140	6 to 1
96	178	4½ to 1
95	180	4½ to 1 } Even
94	150	6 to 1
93	106	9 to 1
92	65	14 to 1
91	35	28 to 1
90	17	58 to 1
89	7	142 to 1
88	3	332 to 1 } 90 to 1
87	1	999 to 1
	1,000 samples.	

Various conclusions can be drawn from Table II. It will be seen that there are 180 chances out of 1,000 (roughly two chances out of 11) that any one sample will be of 95 per cent purity ; in other words, there are only two chances out of 11 that the sample will be of the same purity as the whole consignment, and the odds are nine to two against the sample giving a true representation of the bulk. Out of 1,000 samples, 180 are expected to be 95 per cent pure, and 178, 96 per cent pure ; thus any single sample taken from the consignment is almost as likely to be 96 per cent pure as 95 per cent pure, despite the fact that the consignment averages 95 per cent purity. There is one chance out of two (even odds) that the sample will be 97 per cent, 96 per cent or 95 per cent pure, and a similar chance that it will be 96 per cent, 95 per cent or 94 per cent pure. There are only 11 chances out of 1,000 (odds of 90 to one against) that any one sample will have a purity of less than 90 per cent, and the chances of its being less than 87 per cent are negligible.

Distributions of 99 per cent to 90 per cent mean purity.

If the mean purity of the cacao sampled is not 95 per cent, the distribution obtained by taking a large number of samples will differ from that given for cacao of 95 per cent. purity in Table II. The theoretical distributions for purities of 99 per cent, 98 per cent ..... 90 per cent are given in the following table :—

TABLE III.

DISTRIBUTION OF SAMPLES OF 100 BEANS TAKEN FROM CACAO THAT HAS BEEN THOROUGHLY MIXED BEFORE SAMPLING.

Purity of beans	Mean purity.									
	99%	98%	97%	96%	95% (A)	94%	93%	92%	91%	90%
100%	366	133	48	17	6	2	1			
99	369	271	147	70	31	13	5	2	1	
98	185	273	225	145	81	41	20	9	4	2
97	61	182	228	197	140	86	49	25	12	6
96 (C)	15	90	171	199	178 (B)	134	89	54	30	16
95	3	35	101	159	180	164	128	90	57	34
94		11	50	105	150	166	153	123	89	60
93		3	20	59	106	142	154	144	119	89
92		1	7	29	65	105	135	146	137	115
91			2	12	35	69	104	129	138	130
90			1	5	17	40	71	102	124	132
89				2	7	21	44	73	101	120
88				1	3	10	24	46	74	99
87					1	4	13	28	49	74
86						2	6	15	30	51
85						1	3	7	17	33
84							1	3	9	19
83								2	4	11
82								1	2	5
81									1	3
80										1

Table III may be understood by tracing the letters (A), (B) and (C). If the cacao sampled has a mean purity of 95 per cent (A) there are 178 chances (B) out of 1,000 chances that the purity of a single sample of 100 beans will be 96 per cent (C). Conversely, if the purity of a single sample of 100 beans, drawn from the cacao, is 94 per cent, there are 153 chances out of 1,000 that the mean purity of the cacao will be 93 per cent i.e. between 92.5 per cent and 93.5 per cent.

The distributions for cacao of 98 per cent purity, 95 per cent purity, 90 per cent purity, and 85 per cent purity are portrayed graphically in Plate No. 1. The diagram for 95 per cent purity is less lop-sided (less skew) than that for 98 per cent, the 90 per cent diagram is still less skew, and so on. In fact, a series of curves for declining purity would show progressively less skewness, reaching symmetry at 50 per cent purity.

There are nine purity classes containing one unit or more in the 98% diagram, 14 in the 95 per cent diagram, and 19 in that for 90 per cent. In fact the number of frequency classes in which the purity may be expected to fall at least once out of 1,000 samples becomes greater as the purity is less, reaching 23 classes at 85 per cent purity and 31 classes at 50 per cent purity. In other words, as the purity declines, the deviations from the mean become greater.

Theoretical standard deviation.

These deviations from the mean can be expressed by a figure, called the standard deviation ; and the theoretical standard deviation (σ) for any mean purity can be calculated. Plate II contains a graph from which σ (sigma) may be read ; thus for cacao of 90 per cent purity, σ is 3.00, and for 80 per cent purity, it is 4.00.

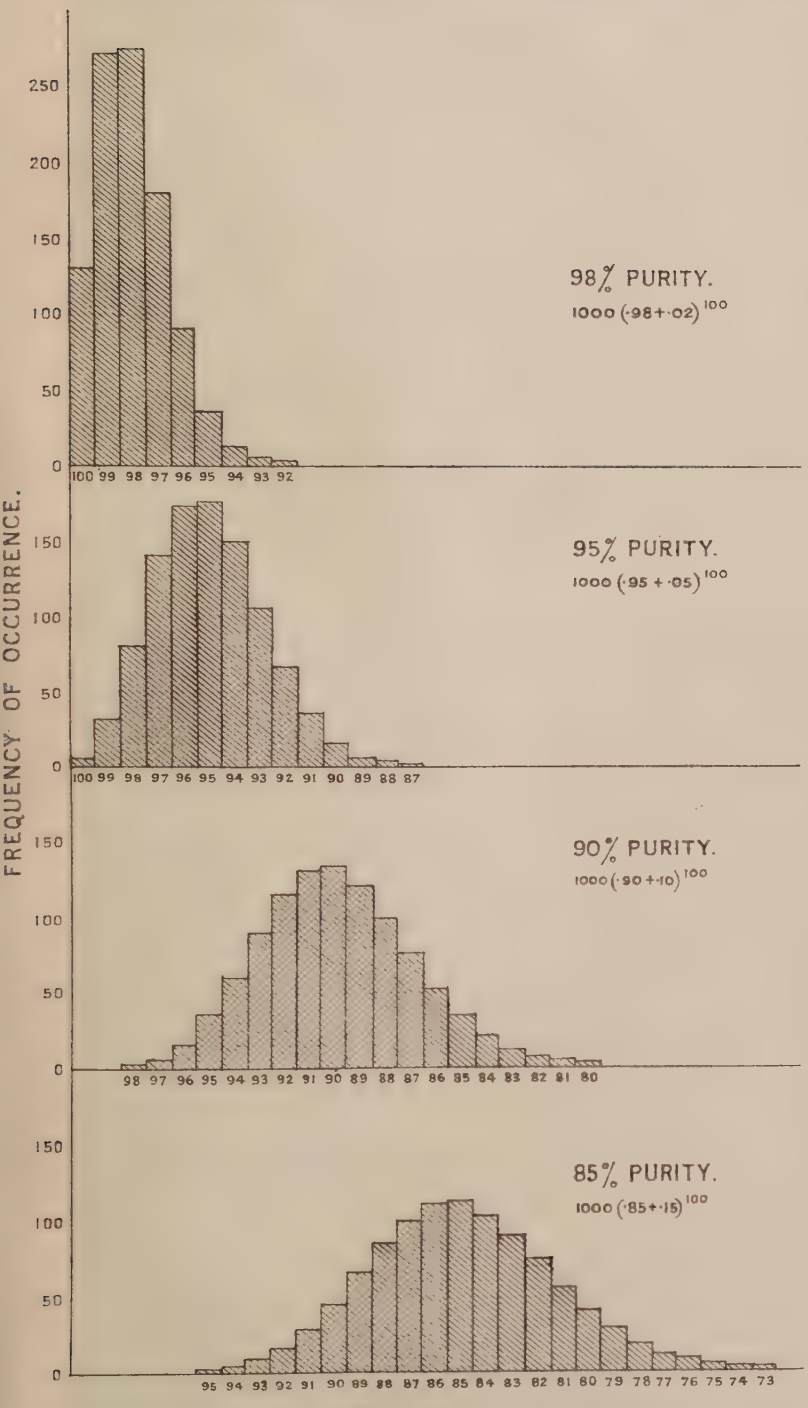
Mathematics of binomial distributions.

In parenthesis, it may be mentioned that the theoretical distributions given in this section are binomial distributions and that proof of their validity rests on the fact that every bean is one of two things, good or not good. Thus the distribution of samples, each of 100 beans, from homogeneous cacao of 95 per cent purity is obtained from the expansion of the binomial series $(.95 + .05)^{100}$, and the theoretical standard deviation (σ) is $\sqrt{.95 \times .05 \times 100}$. If M is the mean purity, then the distribution for 1,000 samples is obtained from $1{,}000 \left(\frac{M}{100} + \frac{100-M}{100} \right)^{100}$ and σ is $\sqrt{\frac{M\,(100-M)}{100}}$

DISTRIBUTION OF SAMPLES FROM ACTUAL CONSIGNMENTS OF CACAO.

The previous section dealt with theoretical distributions obtainable from homogeneous consignments, but in this section attention is directed to the actual distributions obtained from consignments of cacao shipped from the Gold Coast. The sampling figures for seven selected consignments are given in the following table :—

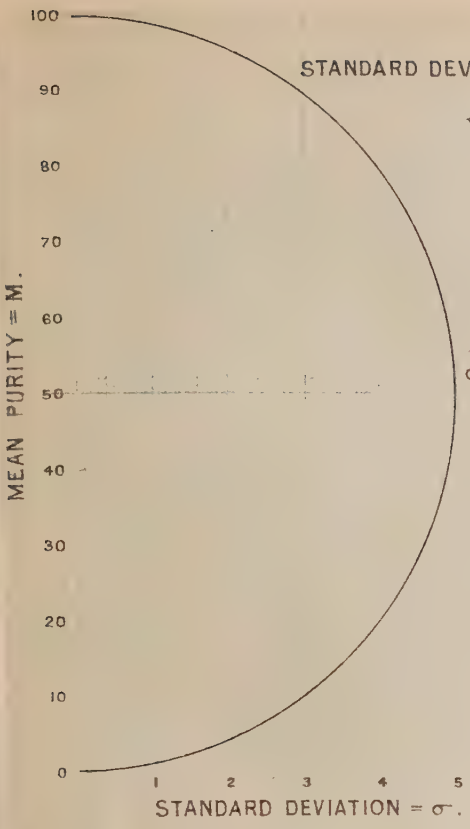
FREQUENCY DISTRIBUTIONS FOR HOMOGENEOUS CACAO
EACH DISTRIBUTION IS FOR 1000 SAMPLES, EACH OF 100 BEANS.



SURVEY H.Q. ACCRA, 1931.

STANDARD DEVIATION OF THE BINOMIAL SERIES.

$$\left\{\frac{M}{100}+\frac{(100-M)}{100}\right\}^{100}$$



$$\sigma=\sqrt{\frac{M}{100}\cdot\frac{100-M}{100}\cdot 100}$$

$$=\sqrt{\frac{M\,(100-M)}{100}}$$

TABLE OF σ FOR MEAN PURITIES RANGING FROM 99·9% TO 90%.

MEAN PURITY	0	·1	·2	·3	·4	·5	·6	·7	·8	·9
99	0·995	0·944	0·891	0·834	0·772	0·705	0·631	0·547	0·447	0·316
98	1·400	1·364	1·327	1·292	1·253	1·217	1·175	1·131	1·086	1·039
97	1·706	1·677	1·650	1·619	1·591	1·559	1·530	1·497	1·466	1·432
96	1·960	1·934	1·910	1·887	1·863	1·836	1·811	1·786	1·758	1·732
95	2·179	2·156	2·135	2·114	2·093	2·071	2·049	2·027	2·005	1·982
94	2·375	2·356	2·337	2·317	2·298	2·278	2·258	2·238	2·218	2·197
93	2·551	2·534	2·516	2·500	2·482	2·464	2·447	2·429	2·410	2·392
92	2·713	2·696	2·681	2·665	2·650	2·632	2·617	2·600	2·584	2·567
91	2·860	2·846	2·832	2·817	2·804	2·787	2·773	2·759	2·742	2·728
90	3·000	2·985	2·972	2·966	2·944	2·931	2·917	2·903	2·890	2·876

EXAMPLE :— WHEN THE MEAN PURITY IS 95·4, σ IS 2·093.

SURVEY H.Q. ACCRA, 1931

TABLE IV.

FREQUENCY DISTRIBUTIONS OF 50 SAMPLES (EACH OF 100 BEANS) FOR CONSIGNMENTS OF CACAO AT GOLD COAST PORTS.

Percentage Purity.	Example No.						
	1.	2.	3.	4.	5.	6.	7.
100	—	—	—	4	3	6	2
99	—	—	—	7	4	4	3
98	1	—	2	8	1	5	2
97	2	1	1	5	4	4	6
96	2	4	4	7	3	2	3
95	5	3	5	5	3	8	—
94	4	3	2	6	2	2	2
93	7	5	4	1	5	3	8
92	4	5	3	1	2	1	5
91	9	9	5	2	1	2	3
90	5	6	5	—	2	4	6
89	3	1	5	2	5	1	—
88	4	1	4	—	2	1	1
87	2	2	3	—	1	2	—
86	1	4	—	1	5	2	—
85	1	3	2	—	—	—	1
84	—	1	1	—	1	—	—
83	—	—	2	—	—	1	1
82	—	1	1	—	1	—	—
81	—	1	—	—	1	—	—
80	—	—	1	—	1	—	—
79	—	—	—	—	1	—	—
78	—	—	—	—	—	—	—
77	—	—	—	—	—	—	—
76	—	—	—	1	—	—	1
75	—	—	—	—	1	—	—
74	—	—	—	—	—	—	2
73	—	—	—	—	—	—	1
72	—	—	—	—	—	1	—
71	—	—	—	—	—	—	—
70	—	—	—	—	—		—
69	—	—	—	—	—	—	—
68	—	—	—	—	—	—	—
67	—	—	—	—	—	—	—
66	—	—	—	—	—	—	—
65	—	—	—	—	—	—	1
64	—	—	—	—	—	—	—
63	—	—	—	—	1	—	—
62	—	—	—	—	—	—	—
61	—	—	—	—	—	—	1
60	—	—	—	—	—	—	—
59	—	—	—	—	—	—	—
58	—	—	—	—	—	—	—
57	—	—	—	—	—	—	—
56	—	—	—	—	—	1	1
Total no. of samples ...	50	50	50	50	50	50	50

The distributions given in Table IV have been drawn graphically in Plate III, in which the shaded portion represents the actual distribution and the curve indicates the thoretical distribution calculated from the mean purity as in Table III and Plate I. One can see at a glance the extent to which the actual distribution (shaded portion) conforms with the theoretical distribution (curve).

In a consignment in which the cacao had been well mixed before bagging nearly all the shaded portion would fall within the horizontal limits of this curve. If a very large number of samples had been taken, the shaded portion and the curve would correspond, but if only 50 samples had been taken (as in the examples in Plate III), some discrepancy between the height of the shaded portion and of the curve is to be expected. Any divergence from the curve is much more serious horizontally than vertically.

In example I Plate III, no sample is outside the horizontal limits of the curve, and the shaded portion conforms as closely with the curve as can be expected of 50 samples; consignment No. 1 therefore was of uniform quality. In example 4, many samples are outside the curve; consignment No. 4, therefore, was of variable quality, i.e. the cacao had not been thoroughly mixed before bagging. In example 7, the deviations of individual samples from the mean are still greater; consignment No. 7, therefore, consisted of a very variable lot. Examples 1 to 7 form a series graduating from a consignment of uniform quality to one of very variable quality.

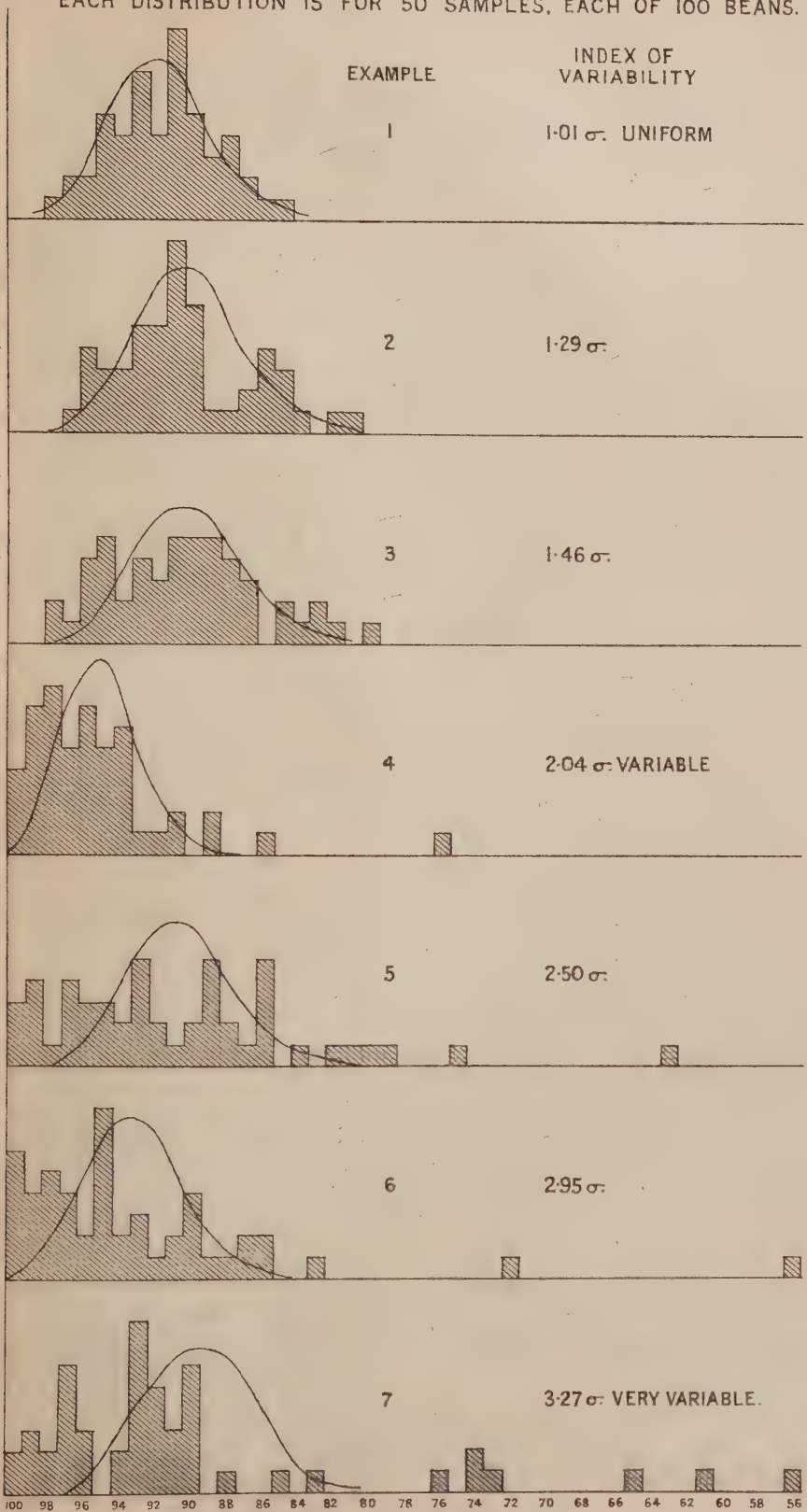
Index of variability.

A measure of the uniformity of a consignment may be calculated in the following way (see Table XXVI for details of arithmetic). First the mean purity of the samples is calculated, and, secondly, the actual standard deviation (S.D.) of the samples from the mean. From the mean purity is calculated the theoretical standard deviation (σ) of a uniformly mixed, or homogeneous, consignment (this figure can be read from Plate II). Then if S.D. equals σ, the consignment is of uniform quality. If S.D. is twice σ, the consignment is a variable lot, and if S.D. is thrice σ, it is of very variable quality.

The mean purity, standard deviation and sigma (σ) of each of the seven consignments of Table IV and Plate III are given in the following table :—

FREQUENCY DISTRIBUTIONS FROM ACTUAL CONSIGNMENTS OF CACAO FROM GOLD COAST PORTS.

EACH DISTRIBUTION IS FOR 50 SAMPLES, EACH OF 100 BEANS.



SURVEY H.Q. ACCRA. 1931.

TABLE V.

MEAN PURITY, S.D., AND σ FOR THE CONSIGNMENTS OF CACAO GIVEN IN TABLE IV.

	Example No.						
	1.	2.	3.	4.	5.	6.	7.
Mean purity	91.74%	90.58%	90.66%	95.60%	90.90%	93.22%	90.06%
Standard Deviation...	2.76	3.78	4.25	4.14	7.17	7.47	9.79
σ	2.73	2.92	2.90	2.03	2.87	2.53	2.99
$\frac{\text{S.D.}}{\sigma}$	1.01	1.29	1.46	2.04	2.50	2.95	3.27
Description ...	Uniform		Slightly Variable		Variable		Very Variable

In example No. 1, S.D. is 1.01 times σ, in example No. 2, S.D. is 1.29 times σ, and so on, S.D. being 3.27 times σ in example No. 7. The quality of the consignments ranges from uniform to very variable.

Hence the actual standard deviation (S.D.) in terms of the theoretical standard deviation (σ) may be used as a criterion of the uniformity or variability of a consignment, as follows:—

TABLE VI.

INDEX OF VARIABILITY.

$\frac{\text{S.D.}}{\sigma}$	Index of variability.	Description.
1.00 — 1.50	1.00σ to 1.50σ	Uniform quality.
1.50 — 2.00	1.50σ to 2.000	Slightly variable.
2.00 — 3.00	2.00σ to 3.00σ	Variable.
Over 3.00	Over 3.00σ	Very variable quality.

Thus in a test of uniformity (or more correctly homogeneity), if the index of variability is 1.40 σ there is insufficient evidence to show that the consignment is even slightly mixed, so it is assumed to be uniform. If the index is 1.60 σ, there is strong evidence of non-uniformity (or more correctly heterogeneity), so the consignment is called slightly variable, and if the index is greater than 2.0 σ, the consignment certainly is a variable lot.

VARIABILITY BETWEEN CONSIGNMENTS.

The index of variability has been calculated for 100 consignments of cacao shipped from Gold Coast ports; the results are given in the following table:

TABLE VII.

UNIFORMITY OF CACAO IN CONSIGNMENTS AT GOLD COAST PORTS.

INDEX OF VARIABILITY = STANDARD DEVIATION/σ = $\frac{\text{S.D.}}{\sigma}$

20 samples.		30 samples.		40 samples.		50 samples.		60 samples.	
20 tons cacao.		60 tons cacao.		100 tons cacao.		170 tons cacao.		250 tons cacao.	
Mean purity	S.D./σ	Mean purity	S.D./σ	Mean purity	S.D./σ	Mean purity	S.D./σ	Mean purity	S.D./σ
97.05	1.08	96.33	1.41	95.90	1.05	91.74	1.01	93.93	1.27
96.40	1.15	95.03	1.46	94.45	1.67	92.36	1.27	90.12	1.33
93.60	1.32	93.50	1.60	94.52	1.68	90.58	1.29	91.38	1.38
93.80	1.50	96.37	1.65	96.42	1.74	90.66	1.46	91.83	1.42
97.15	1.52	95.63	1.69	93.55	1.79	94.58	1.46	89.71	1.50
93.80	1.53	96.13	1.73	96.75	1.84	94.10	1.49	92.12	1.56
95.90	1.66	95.06	1.86	93.25	1.84	92.80	1.63	87.35	1.68
94.15	1.67	92.50	1.88	94.70	1.95	89.76	1.84	92.56	1.72
96.10	1.68	92.50	2.01	93.10	2.05	93.20	1.89	92.18	1.72
93.60	1.88	95.33	2.14	96.07	2.13	93.40	1.98	86.90	1.78
94.40	1.97	93.60	2.34	94.45	2.18	95.60	2.04	92.83	1.92
95.80	2.06	91.96	2.38	88.22	2.24	95.44	2.19	89.16	2.05
92.65	2.11	94.43	2.42	94.36	2.32	91.90	2.28	87.90	2.13
97.35	2.28	93.60	2.47	93.80	2.40	93.70	2.36	88.87	2.17
91.90	3.01	95.40	2.78	93.75	2.47	90.90	2.50	94.43	2.76
89.00	3.07	91.63	3.35	95.40	2.55	91.17	2.53	87.80	2.85
88.35	3.12	94.10	3.50	94.22	2.70	93.22	2.95	84.93	3.84
92.70	3.60	89.43	3.79	94.90	2.92	91.90	3.15	87.90	3.94
91.40	3.75	90.80	3.81	93.17	3.12	90.06	3.27	93.70	4.08
87.40	4.47	88.93	4.46	89.27	3.70	91.40	3.41	89.12	4.88
93.62	2.22	93.61	2.44	94.01	2.21	92.42	2.10	90.24	2.30

Mean of all 92.78% purity.
2.25% mean index of variability.

These consignments were shipped from the Gold Coast during those months, November and December, when the quality compared with other months is high. The average size of the consignment, from which 20, 30, 40, 50 and 60 samples were taken, ranged from 20 tons to 250 tons cacao. The mean purity of consignments ranged from 97.35 to 84.93, and the mean purity of them all was 92.78 per cent.

The consignments may be classified in accordance with Table VI. Out of a total of 100 consignments, 18 were of uniform quality, 30 of slightly variable quality, 32 of variable quality, and 20 of very variable quality. Consignments ranging from 20 tons to 250 tons were equally variable. The actual standard deviation (S.D.) ranged from 1.01 times to 4.88 times the theoretical standard deviation (σ), and, on an average, S.D. was 2.25 times σ. These figures confirm the fact that shipments of local cacao are rarely of uniform quality, and also show that often the quality of a consignment is very variable indeed.

Inspection of Tables IV and V shows that consignments with an index of 2.00 σ to 2.50 σ and over, contained occasional bags of markedly inferior quality. According to Table VII, out of 100 consignments there were 39 that had an index of 2.25 σ and over, so that about four consignments out of 10 contained some bags of exceptionally inferior quality. This ratio will be of use in a subsequent discussion on the occasional bad bag.

VARIABILITY OF QUALITY BETWEEN BAGS AND WITHIN BAGS.

Lack of uniformity in a consignment may occur between bags and within bags. To demonstrate this, two samples, instead of the usual one sample, were taken from each of 50 bags examined out of 2,400 bags shipped from Accra in January, 1931. The percentage of purity of the samples is given in the following table :—

TABLE VIII.

PERCENTAGE PURITY OF PAIRS OF SAMPLES, EACH PAIR BEING FROM A DIFFERENT BAG.

Bag No.	No. of good beans out of 100.		Bag No.	No. of good beans out of 100.		Bag No.	No. of good beans out of 100.	
	Sample No. 1.	Sample No. 2.		Sample No. 1.	Sample No. 2.		Sample No. 1.	Sample No. 2.
1	95	99	21	94	78	41	79	81
2	82	90	22	93	94	42	82	92
3	97	98	23	84	87	43	83	86
4	94	97	24	75	92	44	90	91
5	94	88	25	88	72	45	91	90
6	96	85	26	92	96	46	93	95
7	93	98	27	64	63	47	82	65
8	93	89	28	97	98	48	84	90
9	96	92	29	91	90	49	96	94
10	94	92	30	56	47	50	84	83
11	95	90	31	85	85	—	—	—
12	96	89	32	98	94	—	—	—
13	99	83	33	95	92	—	—	—
14	92	96	34	82	78	—	—	—
15	99	98	35	92	94	—	—	—
16	91	87	36	98	97	—	—	—
17	93	98	37	82	96	—	—	—
18	94	95	38	98	95	—	—	—
19	91	97	39	93	95	—	—	—
20	57	88	40	97	94	—	—	—

As examples of lack of uniformity *between* bags, bag No. 27, showing for two samples a mean purity of 63.5 per cent, and bag No. 30, showing a mean purity of 51.5 per cent, differed widely in quality from the mean purity, 89.12 per cent, of the whole consign-

ment. As examples of lack of uniformity *within* bags, bag No. 20, with samples of 57 per cent and 88 per cent purity, and bag No. 47, with 82 per cent and 65 per cent purity, each showed wide variation in quality in different parts of the same bag.

Clearly the extent to which the purities of bags, calculated from the mean of the two samples from each bag, differs from the mean purity of the consignment gives a measure of the variation between bags. Similarly the difference between each pair of samples gives a measure of the variation within bags. By appropriate statistical methods the variability may be partitioned, as shown in the following table :—

TABLE IX.

Analysis of Variation Between Bags and within Bags from the Samples Recorded in Table viii.

	Degrees of freedom.	Sum of squares.	Variance.	Standard deviation.	S.D. / σ
Between bags ...	49	7,852	160.2	12.66	4.07
Within bags	50	1,662	33.2	5.76	1.85
	99	9,514	96.1	9.80	3.15

Mean purity = 89.12%.
σ (for mean purity 89.12%) = 3.114.
See Table XXVII for method of working.

From the last column it will be seen that the index of variability for all the 50 bags was 3.15 σ, showing that the consignment was very variable in quality. The index of variability was 4.07 σ between bags as against 1.85 σ within bags, showing that lack of uniformity occurred mainly between bags, but that in addition, there was considerable variation within bags. Although the variation between bags was twice as great, that within bags contributed in no small measure to the lack of uniformity of the cacao in the 50 bags.

In the following table are given the results of the only six lots that have been examined in this way :—

TABLE X.

Variability of Cacao Between Bags and within Bags.

1	2	3	4	5	6
Example.	No. of bags.	Mean purity. per cent	Index of variability.		
			Between bags.	Within bags.	Between and within bags.
1	50	89.12	4.07	1.85	3.15
2	40	90.73	4.29	1.13	3.12
3	80	91.42	3.01	1.88	2.51
4	40	90.87	2.37	1.65	2.04
5	40	94.97	1.88	1.38	1.65
6	28	93.64	1.22	0.94	1.09
		Means	2.81σ	1.47σ	2.26σ

In only one case out of six was the index of variability between bags (column 4) below 1.50 σ, whereas within bags (column 5) it was below 1.50 σ in three cases. The variation between bags was, on the average, twice as great as that within bags. On the other hand the lack of uniformity within bags was sometimes considerable, showing that some consignments consist not only of cacao which differs in quality from bag to bag but also of cacao which differs greatly in quality in the different parts of individual bags.

THE OCCASIONAL BAG CONTAINING POOR QUALITY CACAO.

In testing the quality of a consignment, no method of sampling other than testing the cacao in every bag can guarantee to detect the occasional bag containing bad quality cacao. Take the case of a consignment of 1,000 bags, of which 999 are of good quality and one of bad quality. If samples are drawn from 100 bags, there is one chance out of 10 that the bad bag will be detected. If samples are taken from as many as 500 bags, the odds that the bad bag has been missed are even, and, if 999 bags are tested, it is possible that the remaining bag will be the bad bag.

The chances of detecting bad bags can be calculated, in the case of a limited number of bags from the formula

$$\left(1-\frac{\lfloor N-N_B \quad \lfloor N-n}{\lfloor N-N_B-n \quad \lfloor N}\right),$$

where a consignment of N bags contains N_B bad bags, or, in the case of an unlimited number of bags from the formula

$$\left(1-\left(\frac{100-x}{100}\right)^n\right),$$

where the consignment contains x per cent. bad bags. Thus in consignments containing 1 per cent bad bags the odds that the bad bags will not be sampled are even, when 69 samples are taken from a consignment of unlimited size, when 66 are taken from 1,000 bags, 65 from 500 bags, 58 from 200 bags, and 50 from 100 bags. The last is self-evident, because the bad bag is likely to occur with equal frequency in the 50 bags sampled and in the 50 bags unsampled.

If samples are taken from 100 bags of a large consignment, the chances are against the detection of bad bags comprising 0.5 per cent or less and in favour of the detection of 1 per cent or more. Thus if 100 samples are taken from a consignment of 6,000 bags, there may quite possibly be 30 undetected bad bags (0.5 per cent) in the consignment ; there are 366 chances of failure to detect 60 bad bags as against 634 chances of detection, and 6 chances out of 1,000 that 300 bags in the consignment would be unsampled and undetected.

The exact number of samples may be calculated for given percentage purities and given levels of probability, as shown in the following table ;—

TABLE XI.

NUMBER OF SAMPLES OF GIVEN PERCENTAGE PURITIES AND GIVEN LEVELS OF PROBABILITY.

Chances of drawing a sample from bags specified.	4.7 to 1 against (.175).	5 to 3 against (.375).	Even odds (.5).	2 to 1 on (.667).	4 to 1 on (.800).	9 to 1 on (.900).
No. of specified bags per cent (unlimited population).			Number of samples.			
0.01	1,900	4,700	7,000	11,000	16,000	23,000
0.05	380	940	1,400	2,200	3,200	4,600
0.1	190	470	700	1,100	1,600	2,300
0.5	38	94	140	220	320	460
1.0	19	47	69	108	160	230
2.0	9	23	34	54	79	114
3.0	6	15	23	36	53	76
4.0	5	12	17	27	40	57
5.0	4	9	14	21	31	45
7.5	3	6	9	14	21	30
10.0	2	4	7	10	15	22
Odds against the consignment containing above percentage of bad bags if no bad bag detected in sampling.	2 to 1 against	3 to 1 against	4 to 1 against	13 to 2 against	11 to 1 against	24 to 1 against

Thus, if a large consignment contains 10 per cent bad bags, and if seven samples are taken, the odds are even that the bad bags will be detected or undetected. On the other hand, if seven samples are taken from a very large consignment containing an unknown number of bad bags, the odds that the consignment contains 10 per cent bad bags are not even. The consignment may contain no bad bags at all, and, as previously stated, only 40 consignments, out of 100 consignments examined, contained such bags. Assuming that 4 consignments out of 10 contain occasional bad bags, and assuming that the seven samples drawn were not of markedly inferior quality, the probability that the consignment contains 10 per cent bad bags is $\frac{4}{10} \times \frac{5}{10}$, equivalent to odds of four to one against. Thus a buyer of 3,000 bags of cacao might be satisfied to know that the odds were over 10 to one against the consignment containing 30 bags of exceptionally inferior quality cacao (one per cent); this would be the case if 160 samples, drawn from separate bags and examined individually, were found not to be of markedly inferior quality (Table XI).

The odds given at the base of Table XI should be used with caution, because the ratio of four consignments containing occasional bad bags to six consignments not containing such bags was derived from 100 consignments exported during the months of November and December, when quality is usually at its best. The mean purity of these consignments was 92.78 per cent as against 85 per cent for a whole year. Consequently it is possible that more than half of the consignments exported contain a few bags of exceptionally poor quality.

It should be noted that every sample has to be examined separately; if they are bulked, it is not possible either to detect bad bags or to state the chances that bad bags have been undetected.

SINGLE SAMPLE OF 100 BEANS AS A TEST OF THE QUALITY OF A BAG.

It has been shown that, when a single sample of 100 beans is taken from cacao that has been throughly mixed, this sample often will not give a true representation of the bulk, because of the error inherent in random sampling. It has also been shown that the quality of cacao frequently differs widely in different parts of the same bag. Evidently, therefore, a single sample of 100 beans taken from a bag of cacao will often give a false impression of the contents of the bag.

The chances that the cacao will be of a different purity from the sample can be calculated, in the case of a cacao that has been throughly mixed before sampling, from Table III. Thus, if the purity of a single sample of 100 beans is 95 per cent, there are 35 chances out of 1,000 that the mean purity of the cacao is about 98 per cent, and almost the same number of chances that it is about 90 per cent. To gain an accurate picture of the contents of the bag it would be necessary to take more samples and compute the mean.

Because the variation within a bag is usually less than within a consignment, and because the number of samples within a bag is limited (to about 400 samples), fewer samples need be taken in sampling a bag than in sampling a consignment in order to obtain the mean purity with the same degree of accuracy. It can be shown—from the figures given in this paper for variability within bags and within consignments—that if the mean purity of an average consignment were estimated from 20 samples the number of samples required to be taken from an average bag in order to gain as accurate an estimate of the mean purity of that bag would be eight samples, and from a bag of well-mixed cacao, four samples. To take a sample of 400 to 800 beans from one bag would be absurd in practice. Clearly, there is no practicable method of sampling that can give a reliable estimate of the mean purity of each bag sampled.

CHANCES OF SAMPLES FALLING BELOW A SPECIFIED PURITY.

The chances that any sample will show a purity of less than a given purity can also be calculated from Table III. Thus, in the case of cacao of 95 per cent purity there are 11 chances (7+3+1) out of 1,000 that a single sample will be less than 90 per cent purity.

A table for 95 per cent mean purity is given below :—

TABLE XII.

CHANCES OF A SINGLE SAMPLE FALLING BELOW A SPECIFIED PURITY. MEAN PURITY OF CACAO—95 PER CENT.

Purity of single sample.	No. of chances out of 1,000 that the purity of a single sample will be less than purity specified.	Odds against the purity of a single sample being less than purity specified.
Per cent.	Approximately	Approximately
95	384	1.6 to 1
94	234	3.3 to 1
93	128	6.8 to 1
92	63	15 to 1
91	28	34 to 1
90	11	90 to 1
89	4.3	230 to 1
88	1.5	660 to 1
87	0.5	2,000 to 1
86	0.2	5,000 to 1

Thus, from cacao of mean purity 95 per cent, a sample of purity less than 90 per cent might be expected to occur 11 times in 1,000 trials, or once in 91 trials. Hence the drawing of a single sample of less than 90 per cent purity from cacao that has been thoroughly mixed is strong evidence that the mean purity of the cacao is less than 95 per cent. Similarly, the occurrence in ten samples of one sample below 90 per cent purity is a good indication that the mean purity of the cacao is less than 95 per cent.

ERROR OF THE MEAN.

The usual method of expressing the error of the mean is by the "standard error", which is calculated by dividing the standard deviation by the square root of the number of samples analysed.

Theoretical Standard Error.

In the case of cacao of a mean purity of 90 per cent, the theoretical standard deviation (σ) for a uniformly mixed, or homogeneous, consignment is 3.00 (see Plate II). If 25 samples be taken, then the theoretical standard error (ε) is 3.00 divided by the square root of 25 ; thus :—

$$\varepsilon = \frac{\sigma}{\sqrt{n}} = \frac{3.00}{\sqrt{25}} = \frac{3}{5} = 0.6$$

It is therefore probable that the mean of the 25 samples will lie within 90 ± 0.6, i.e., between 90.6 and 89.4.

Actual Standard Error.

In the example given in Table XXVI, the actual standard deviation (S.D.) is 2.687, and the number of samples (n), 40 ; hence the actual standard error (S.E.) of the mean purity (96.075) is 2.687 divided by the square root of 40; thus:—

$$\text{S.E.} = \frac{\text{S.D.}}{\sqrt{n}} = \frac{2.687}{\sqrt{40}} = \frac{2.687}{6.325} = 0.425$$

It is therefore probable that the true mean lies within 96.075 ± 0.425, i.e., between 96.5 and 95.65. The odds are about two to one against the true mean being outside this range.

Standard Errors of Actual Consignments.

The standard errors of the 100 consignments shown in Table VII have been calculated, and the results are given in the following table :—

TABLE XIII.

STANDARD ERRORS OF ANALYSES OF SAMPLES TAKEN FROM CONSIGNMENTS AT GOLD COAST PORTS.

1	2	3	4	5	6	7
No. of consignments.	No. of samples from each consignment.	Mean purity.	Standard Error (S.E.).			$\varepsilon = \frac{\sigma}{\sqrt{n}}$ (calculated from mean purity).
			Lowest error in the 20 consignments.	Mean error of 20 consignments.	Highest error in the 20 consignments.	
20	20	93.62	0.42	1.21	3.33	0.55
20	30	93.61	0.50	1.09	2.55	0.45
20	40	94.01	0.34	0.83	1.83	0.38
20	50	92.42	0.39	0.79	1.38	0.37
20	60	90.24	0.45	0.88	1.97	0.38
Mean of all ...		92.78		0.96		0.426

In Table XIII the mean standard error (column 5) was, on an average, 2.25 times greater than the theoretical error (column 7). This figure of 2.25 is, of course, the same as the mean index of variability given in Table VII, because

$$\frac{\text{S.E.}}{\varepsilon} = \frac{\frac{\text{S. D.}}{\sqrt{n}}}{\frac{\sigma}{\sqrt{n}}} = \frac{\text{S. D}}{\sigma}.$$

Conversely, if the index of variability is twice σ, the error to which the estimate of the mean purity is liable is twice what the error would have been if the cacao had been thoroughly mixed before sampling.

The highest standard error (column 6) in each group of 20 consignments averages 2.25 times the mean error (column 5), i.e., $(2.25)^2$ times the theoretical error (column 7).

Standard errors between bags and within bags.

The standard errors of the six consignments shown in Table X are given below :—

TABLE XIV.

STANDARD ERRORS OF ANALYSES OF PAIRS OF SAMPLES, EACH PAIR BEING FROM A DIFFERENT BAG.

No. of consignments 6
No. of samples from each consignment ... ... 46 (approx.)
Mean purity ... ... 91.8 per cent.

1	2	3	4	5
	Standard error.			$\mathcal{E}=\frac{\sigma}{\sqrt{n}}$
	Lowest.	Mean.	Highest.	
Between bags	0.56	1.16	1.96	
Within bags	0.43	0.60	0.82	0.41
Between and within bags ...	0.50	0.93	1.43	

The mean error between bags is nearly twice that within bags, and it is 2.8 times the theoretical error ($\mathcal{E}$). The mean error within bags is 1.5 times the theoretical error for homogeneous cacao.

Comparison of standard errors, theoretical and actual.

The mean error of all groups of consignments sampled is greater than the theoretical standard error $\mathcal{E}$. The mean error of

(*a*) One hundred consignments is 2.25 times $\mathcal{E}$.
(*b*) Five worst consignments out of 100 is $(2.25)^2$ times $\mathcal{E}$. ($5\mathcal{E}$ approx.)
(*c*) Six consignments, between bags, is 2.8 times $\mathcal{E}$.
(*d*) Six consignments, within bags, is 1.5 times $\mathcal{E}$.

From these basic figures may be calculated the approximate mean errors for any number of samples for cacao of any specified purity. This has been done for cacao of 90 per cent mean purity in the following table :—

TABLE XV.

Standard Error of the Mean for Cacao of 90 per cent Mean Purity.

($\sigma = 3.00$)

No. of Samples.	1.	5.	10.	15.	20.	30.	40.	50.	60.	70.	80.	90.	100
ε	3.00	1.34	0.95	0.77	0.67	0.55	0.47	0.42	0.39	0.36	0.34	0.32	0. 30
S.E. of consignments sampled	6.75	3.02	2.13	1.74	1.51	1.23	1.07	0.95	0.87	0.81	0.75	0.71	0.675
S.E. of worst consignments (5 %)	15.00	6.71	4.74	3.87	3.36	2.74	2.37	2.12	1.94	1.80	1.68	1.58	1. 50
S.E. between bags	8.40	3.76	2.65	2.17	1.88	1.53	1.33	1.19	1.08	1.01	0.94	0.88	0.84
S.E. within bags	4.50	2.01	1.42	1.16	1.01	0.82	0.71	0.64	0.58	0.54	0.50	0.47	0. 45

This table may be interpreted as follows. If the mean purity of 20 samples from homogeneous cacao were 90 per cent, the expected error would be 0.67, and the true mean purity of the cacao would be expected to be between 90 + 0.67 and 90 — 0.67 in two trials out of three. In practice, with actual consignments of Gold Coast cacao, the error is most likely to be 1.51, ranging between 0.67 and 3.36 according to the variability of the consignment. It is possible that the true mean will be as high as 93.36 and as low as 86.64, and occasionally outside these limits. The extent to which the error is likely to be due to variability between bags and within bags is indicated by the errors 1.88 and 1.01 respectively.

The figures in Table XV have been graphed in Plate IV, which shows at a glance the errors observed in practice as compared with those possible in theory. Errors as low as those possible in theory can be obtained for cacao that has been thoroughly mixed before sampling, i.e. from cacao of uniform quality. By using the same basic ratios graphs similar to those drawn in Plate IV may be constructed for cacao of purity other than 90 per cent.

THE MAGNITUDE OF THE ERROR.

Effect of Variability on the Magnitude of the Error.

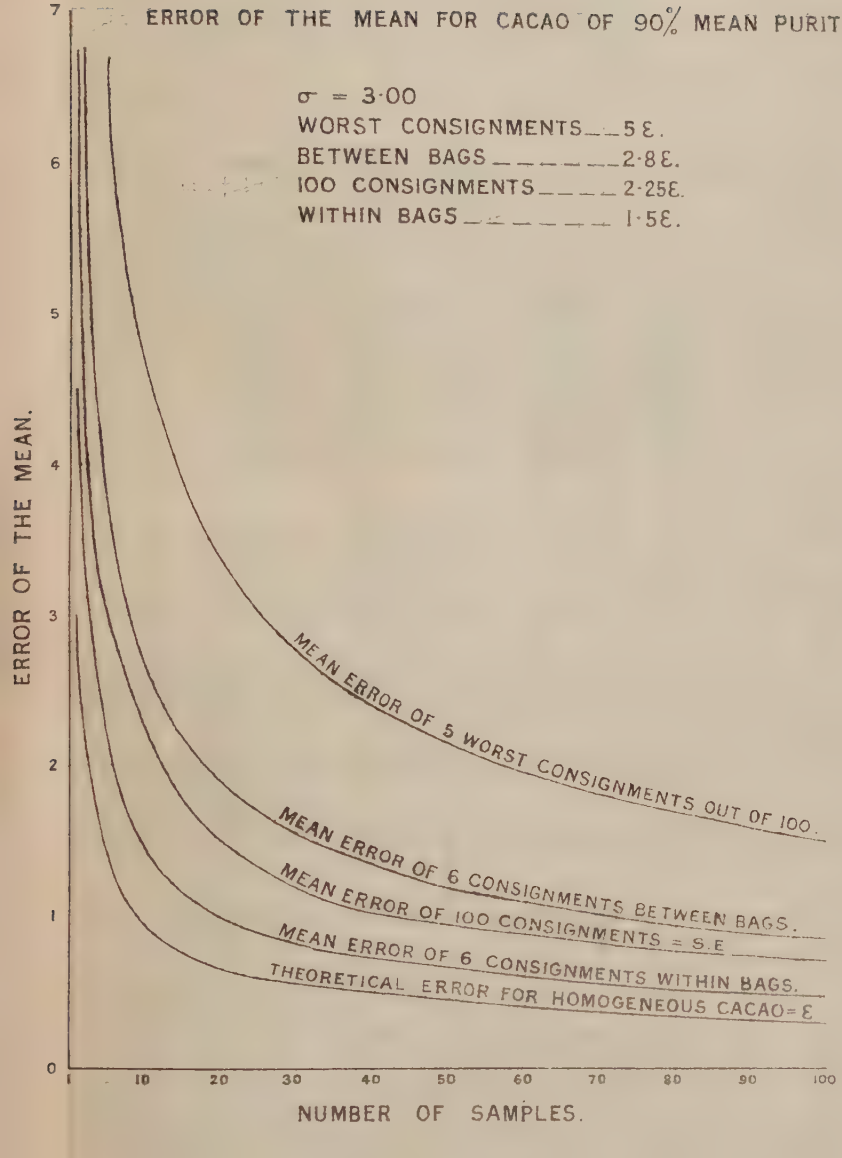
The variability of a consignment greatly reduces the precision of the sampling figures. Referring to Table XV, ten samples from homogeneous cacao have a standard error (E) of 0.95, and the same standard error (S.E.) of 0.95 for actual consignments is not obtained until 50 samples have been taken. Similarly, it would be necessary to take 250 samples from very variable consignments before the standard error would be lowered to 0.95. Conversely, if the standard error of the mean purity of a very variable consignment were found to be 1.50 from 100 samples, as accurate an estimate of the mean purity of an average consignment could be obtained from 20 samples, and in the case of a consignment of uniform quality from four samples. The number of samples required to obtain equal accuracy for the three quality classes ' uniform,' ' variable ' and ' very variable ' is in the proportion of 1 : 5 : 25.

Again referring to Table XV, in the case of 50 samples the standard error of consignments sampled was ± 0.95 as against an error of ± 0.42 for a consignment of uniform quality. The difference between these two figures, ± 0.53, is the part of the error that is due to variability. Hence the error due to variability (± 0.53) was on an average, greater than the sampling error (± 0.42). In very variable consignments the error due to variability was more than four times the sampling error.

Effect of Purity on the Magnitude of the Error.

It has been shown that the standard error is dependent on the standard deviation, and that the standard deviation of homogeneous cacao is greatest for cacao of 50 per cent purity and less for cacao of high purity (Plate II). It follows that the standard error is also

PLATE IV.



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less for cacao of high purity. In the case of average consignments of cacao, assuming as before that S.E. is 2.25 times E, the standard errors for consignments of 98 per cent, 95 per cent, 90 per cent and 80 per cent can be calculated for comparison, as in the following table :—

TABLE XVI.

STANDARD ERROR OF THE MEAN FOR AVERAGE CONSIGNMENTS OF DIFFERENT PURITIES

$$S.E. = \frac{2.25 \times \sigma}{\sqrt{n}}$$

Mean purity.	98 per cent.	95 per cent.	90 per cent.	85 per cent.	80 per cent.
No. of Samples.					
1.	3.15	4.90	6.75	8.03	9.00
5.	1.41	2.19	3.02	3.59	4.02
10.	1.00	1.55	2.13	2.54	2.85
15.	.81	1.26	1.74	2.07	2.32
20.	.70	1.10	1.51	1.80	2.01
30.	.58	.90	1.23	1.47	1.64
40.	.50	.77	1.07	1.27	1.42
50.	.45	.69	.95	1.14	1.27
60.	.41	.63	.87	1.04	1.16
70.	.38	.59	.81	.96	1.08
80.	.35	.55	.75	.90	1.01
90.	.33	.52	.71	.85	.95
100.	.315	.49	.675	.80	.90

This table refers to cacao consignments of average variability. It may be seen that the standard error of ten samples taken from a consignment having a mean purity of 98 per cent is 1.00. To get a similar error of 1.00 for a consignment of 95 per cent purity it is necessary to take about 25 samples, for 90 per cent about 45 samples, and for 80 per cent over 80 samples. If 50 samples are taken, the error for cacao of 98 per cent purity is 0.45, and for 95 per cent purity, 0.69 or half as much again. For cacao of lower purity the error is still greater. Consequently, in any system of sampling that is based on the number of bags, the estimate of the mean purity is more accurate when the mean purity is high than when it is low. To get the same accuracy as in sampling cacao of 98 per cent purity it would be necessary to take eight times the number of samples for cacao of 80 per cent purity. In fact, if M′ and M″ were the mean purities of two consignments, the number of samples required for similar accuracy would be in the ratio of M′ (100–M′) to M″ (100–M″).

Combined Effect of Variability and Low Quality.

It has been shown that, in order to secure the same accuracy as from ten samples from homogeneous cacao, it is necessary to take 50 samples from cacao of variable quality, and 250 samples from very variable cacao. Similarly, for accuracy equal to that

to be obtained from 30 samples of 95 per cent purity, it is necessary to take 80 samples from cacao of 85 per cent purity. Consequently, in order to obtain the same precision as from ten samples of homogeneous cacao of 85 per cent purity, it would be necessary to analyse 133 samples from variable cacao of 85 per cent purity, and over 650 samples from very variable cacao of 85 per cent purity. There are practical difficulties in taking so many samples and examining them separately. Clearly, any method of sampling cacao of variable and poor quality must be very much less accurate than sampling cacao of uniform and good quality.

Effect of Increasing the Number of Samples.

Another point to notice is that the accuracy does not increase in proportion to the number of samples. The gain in accuracy is great from one to 20 samples, appreciable from 20 to 40, small from 40 to 100, and so on. This is brought out clearly in the following table :—

TABLE XVII.

DECREASE IN ERROR FOR AVERAGE CONSIGNMENTS DUE TO INCREASING THE NUMBER OF SAMPLES.

Mean purity 95 per cent. S.E. $= \frac{2.25\ \sigma}{\sqrt{n}}$

No. of samples.	Standard error.	Decrease in error due to 10 additional samples.
1	4.90	
10	1.55	3.35
20	1.10	.45
30	.90	.20
40	.77	.13
50	.69	.08
60	.63	.06
70	.59	.04
80	.55	.04
90	.52	.03
100	.49	.03
No. of samples.	**Standard error.**	**Decrease in error due to 20 additional samples.**
120	.45	.04
140	.41	.04
160	.39	.02
180	.37	.02
200	.35	.02
220	.33	.02
240	.316	.014
260	.304	.012
280	.293	.011
300	.283	.010

The decrease in error by taking 50 instead of 40 samples is 0.08, whereas the decrease by taking 300 samples instead of 280 samples is only 0.01. The gain in accuracy from 40 to 50 samples (error decrease of 0.08) is greater than the gain from 200 to 300 samples (error decrease of 0.067). So far as the accuracy of the mean purity is concerned, the futility of taking a very large number of samples is obvious, and 20 to 100 samples are adequate for normal needs, depending on the variability and purity of the consignment.

In testing the effect of increasing the number of samples on mean purity, on the standard deviation and on the standard error, trials were made with a consignment having an index of variability of 2.9σ. Two hundred and forty samples were taken at random, and the statistics were calculated for samples one to ten, one to 20, one to 30, and so on.

TABLE XVIII.

THE EFFECT OF INCREASING THE NUMBER OF SAMPLES.

Samples.	Mean purity.	S.D.	S.E.	Samples.	Mean purity.	S.D.	S.E.
1 — 10	84.90	12.68	4.04	1 — 130	88.42	9.13	0.80
1 — 20	87.90	11.06	2.47	1 — 140	88.28	9.07	0.77
1 — 30	86.27	11.18	2.04	1 — 150	88.42	8.87	0.72
1 — 40	86.87	10.63	1.68	1 — 160	88.28	9.18	0.73
1 — 50	86.86	10.84	1.53	1 — 170	88.40	9.05	0.69
1 — 60	87.75	10.35	1.34	1 — 180	88.40	8.92	0.67
1 — 70	87.94	9.98	1.19	1 — 190	88.41	8.89	0.64
1 — 80	88.32	9.61	1.07	1 — 200	88.30	9.19	0.65
1 — 90	88.23	9.33	0.98	1 — 210	88.77	9.46	0.65
1 — 100	88.21	9.62	0.96	1 — 220	88.25	9.23	0.62
1 — 110	88.34	9.44	0.90	1 — 230	88.33	9.24	0.61
1 — 120	88.15	9.38	0.84	1 — 240	88.24	9.34	0.60

From one to 70 samples the mean purity differed slightly from the mean purity of the 240 samples, but from 80 to 240 samples it was almost constant. The standard deviation also remained fairly constant from 80 to 240 samples. The additional 160 samples, from 80 to 240, added little to the accuracy of the sampling.

Further tests confirmed these results. In one trial, the figures were recorded for 32 lots of five samples, which were grouped to form 16 lots of ten samples, eight lots of 20 samples, four lots of 40 samples, and two lots of 80 samples, giving the following results :—

TABLE XIX.

EFFECT OF TAKING A GREATER NUMBER OF SAMPLES.
(INDEX OF VARIABILITY 2.84 σ).

No. of lots.	No. of samples in one lot.	Mean purity.			Standard deviation.		
		Highest.	Mean.	Lowest.	Highest.	Mean.	Lowest.
32	5	93.20		78.4	16.27		3.16
16	10	92.20		83.0	12.80		3.90
8	20	90.05		85.85	11.06		6.64
4	40	89.77		86.87	10.60		8.52
2	80	88.32		88.22	9.61		8.71
1	160		88.27			9.17	

In this case there were considerable differences from five to 80 samples, but not between 80 and 160 samples.

A further demonstration of this point was made by examining the figures from ten lots each of 5, 10, 20, 40, 60, 80, and 100 samples respectively, i.e. a total of 2,550 samples from one consignment. All the figures are not given here, but the main results are in the following table :

TABLE XX.

VARIATION DUE TO NUMBER OF SAMPLES.
(MEAN PURITY 89.39 ; STANDARD DEVIATION 6.455 ;
INDEX OF VARIABILITY 2.1 σ).

No of samples.		5	10	20	40	60	80	100
Mean purity	Highest out of 10 lots	93.80	92.60	90.80	90.07	89.87	90.39	89.99
	Lowest out of 10 lots	84.60	88.20	87.65	88.25	89.07	88.64	88.63
	Difference between highest and lowest	9.20	4.40	3.15	1.82	0.80	1.75	1.36
	Theoretical Standard error (Plus or Minus)	2.89	2.04	1.44	1.02	0.83	0.72	0.65
Standard deviation	Highest out of 10 lots	7.68	8.43	7.50	7.47	6.89	6.98	6.93
	Lowest out of 10 lots	2.96	4.36	3.86	5.67	5.90	5.91	6.13
	Difference between highest and lowest	4.72	4.07	3.64	1.80	0.99	1.07	0.80
	Theoretical Standard error (Plus or Minus)	2.04	1.44	1.02	0.72	0.59	0.51	0.46
Standard errors of mean purities	Highest out of 10 lots	3.44	2.67	1.68	1.18	0.89	0.78	0.69
	Lowest out of 10 lots	1.33	1.38	0.86	0.90	0.76	0.66	0.61
	Difference between highest and lowest	2.11	1.29	0.82	0.28	0.13	0.12	0.80

Again, the estimates of the mean purity and of the standard deviation were not improved greatly by analysing more than 60 samples. This confirms the previous conclusion that 20 to 100 ' hundred-bean ' samples are usually adequate in practice.

Effect of Variability between Bags and within Bags.

If the variability between bags is the same as the variability within bags, the consignment of the cacao may be considered to consist of the very large number of potential samples—for all practical purposes an infinite number for consignments of 100 to 10,000 bags. In this case, 50 samples taken at random from the consignment will give the same accuracy, irrespective of the number of bags. If, however, the variability occurs between bags only, and not within bags, the consignment may be regarded as so many bags—in this case consisting of a limited population equal to the number of bags. In order to get the same accuracy, fewer samples need be taken from the smaller consignments, as shown in the following table :—

TABLE XXI.

NUMBER OF SAMPLES FOR SAME LEVEL OF ACCURACY IN AN UNLIMITED AND LIMITED POPULATION.

No. of bags (N).	100	250	500	1,000	2,500	5,000	10,000
*No. of samples (n′) if consignment regarded as an unlimited population.	50	50	50	50	50	50	50
†No. of samples (n″) if consignment regarded as a limited population equal to the number of bags.	34	42	46	48	49	49	50

$$*n' = \frac{1}{K} = 50$$

$$†n'' = \frac{N}{K\,(N-1) + 1}$$

In practice, however, variation in quality is not usually between bags only, but also within bags, so that the precision is constant at some point between n′ and n″. This means that the estimate of the mean purity of 10,000 bags obtained from 50 samples is as accurate as the estimate of the mean purity of 100 bags obtained from about 38 samples (between 34 and 50), provided that the mean purity and variability in quality are the same for the two consignments.

CHANCES OF TRUE MEAN PURITY BEING BELOW SPECIFIED PURITY.

The main requirement in cacao sampling is to know whether the quality is likely to be lower than a certain standard. If the mean purity of the samples is 95 per cent we may wish to know the probability of the mean purity of the consignment being less than 93 per cent. The chances can be calculated, as given in the following table :—

TABLE XXII.

CHANCES OF TRUE MEAN PURITY BELOW A SPECIFIED PURITY.
(DERIVED FROM THE BINOMIAL CURVE $(.90+.10)^{100}$)

Amount by which the estimate of mean purity exceeds a specified purity divided by standard error.	Approximate " odds " against the true mean purity being less than the specified purity.	
.0	1 : 1	
.4	2 : 1	Quite possible
.7	3 : 1	
1.00	5 : 1	
1.25	7 : 1	
1.50	10 : 1	Unlikely
1.75	15 : 1	
2.00	25 : 1	Most unlikely
2.25	42 : 1	
2.50	76 : 1	Almost certainly not
3.00	250 : 1	

This table refers to cacao of 90 per cent purity. Although the odds are slightly smaller for cacao of a purity greater than 90 per cent the table is accurate enough for practical use with purities of 80 per cent to 98 per cent.

The table may be used as follows. An inspector has examined ten samples and found that the mean purity of the samples is 96.5 and that the standard error of the mean is 0.75. He wishes to know if the true mean purity of the cacao is 95 per cent or less. The estimate of the mean purity, 96.5 per cent, exceeds the specified purity, 95 per cent, by 1.5, which divided by the error of the mean, 0.75, gives two. The table shows that, for 2.0, the odds against are 25 : 1, so that the true mean purity is most unlikely to be less than 95 per cent.

BULK SAMPLING.

Instead of examining each sample drawn, the samples may be bulked and thoroughly mixed, and a few ' lots ' of 100 beans drawn from the bulk and examined. This method is called ' bulk sampling'.

Errors in Bulk Sampling.

The error involved in bulk sampling is in two parts. The first part occurs because the samples may not be truly representative of the consignment, and its magnitude may be obtained by dividing the standard deviation (S.D.) by the square root of the number of original samples (calculated as in Table XXVI). The second part of the error occurs because the 'lots' examined may not be truly representative of the bulked samples.

Additional Error Due to Bulking.

The magnitude of the second part of the error may be obtained from the standard deviation (S.D.) of the lots examined, but, if the mixing has been thorough, it is permissible to make use of the theoretical standard deviation (σ); in this case its magnitude is obtained by dividing σ by the square root of the number of lots of 100 beans taken from the bulked samples.

Standard errors, calculated for the second part of the total error, are given in the following table :—

TABLE XXIII.

STANDARD ERRORS FOR BULKED SAMPLES ($\mathcal{E} = \sigma / \sqrt{n}$).

1.	2.	3.	4.
	No. of lots of 100 beans examined from a bulk sample that had been thoroughly mixed.		
Mean purity.	(A) 5 lots	10 lots	20 lots
%	(500 beans).	(1,000 beans).	(2,000 beans)
99	0.45	0.32	0.22
98	0.63	0.44	0.31
97	0.76	0.54	0.38
96 (B)	0.88 (C)	0.62	0.44
95	0.97	0.69	0.49
90	1.34	0.95	0.67
85	1.60	1.13	0.80
80	1.79	1.27	0.89
70	2.05	1.45	1.03
60	2.19	1.55	1.10
50	2.24	1.58	1.12

The letters in parenthesis help to explain this table. If the examination of five lots (A) of 100 beans from the bulk sample gives a mean purity of 96 per cent (B), the standard error may be

expected to be 0.88 (C). Hence although the most probable mean purity of the bulk sample is 96 per cent, it may differ from this purity and, in fact, may be expected to be greater than 96.88 per cent or less than 95.12 per cent in one trial out of three.

Correction for Limited Size of Bulk Sample.

Table XXIII refers to an unlimited population, but, in practice the 'lots' examined are taken from a 'bulk sample' of known size. In order to compensate for this, the standard error should be multiplied by $\sqrt{\frac{N-n}{N-1}}$ where n lots are taken from N samples.

TABLE XXIV.

TABLE OF $\sqrt{\frac{N-n}{N-1}}$. MULTIPLICAND FOR STANDARD ERRORS OF BULKED SAMPLES.

No. of original samples (each of 100 beans approx.) N.	No. of lots of 100 beans examined from a bulk sample that had been thoroughly mixed. 5 lots (500 beans) n′	10 lots (1,000 beans) n″	20 lots (2,000 beans) n‴
10	.745	.000	.000
20	.889	.726	.000
30	.929	.830	.587
40	.947	.877	.716
50	.958	.904	.783
60	.966	.921	.828
70	.971	.933	.851
80	.974	.941	.872
90	.977	.948	.887
100	.980	.953	.899
150	.987	.969	.934
200	.990	.977	.951
300	.993	.984	.968

It will be seen that the multiplicand becomes nearer to unity, as the number of original samples becomes larger, and that the correction is hardly worth applying for 150 bulked samples or over.

Examples of Bulk Sampling.

As an example of bulk sampling the figures in Table XXVI may be used. From 1,600 bags were taken 40 samples, which gave a mean purity of 96.075 with a standard deviation (S.D.) of 2.687. The standard error was $\frac{\text{S.D.}}{\sqrt{N}} = \frac{2.687}{\sqrt{40}} = 0.425$.

Instead of examining the 40 samples (N) suppose that they had

been bulked, thoroughly mixed, and ten lots (n) of 100 beans examined, giving a mean purity for the 10 lots of 95.3. The error due to bulking is

$$\frac{\sigma}{\sqrt{n}} \times \sqrt{\frac{N-n}{N-1}} = \frac{2.114}{10} \times \sqrt{\frac{40-10}{40-1}} = .668. \times .877 = 0.585.$$

The total error is therefore :—

(i)	error between consignment and samples	0.425
(ii)	error between samples and lots	0.585
	Total error	1. 01

The effect of bulking the samples was to double the error. Suppose, however, that the consignment had been of average variability with S.D. 6.75 instead of 2.687 ; then error (i) would have been 1.067, and error (ii), 0.585 as before, the total error being 1.652. In this case the effect of bulking the samples would have been to increase the error by half.

Evidently, therefore, bulking the samples results in loss of accuracy. The method of taking a bulk sample from a consign- and examining only 500 beans results in a large increase in the error (*see* Table XXIII) and when as many as 1,000 beans are examined the increase in error is considerable. It is desirable, however, to discover whether the method could not be improved by taking a larger number of original samples. Thus in sampling a consignment of 3,600 bags, instead of taking 60 samples and examining them separately, one could take 360 samples (10 per cent of the bags), and, after thoroughly mixing, examine ten lots (each of 100 beans) from the bulk sample. In this case the samples drawn, being six times the number, would be more representative of the consignment, and the work of cutting the beans would be reduced by one-sixth, as compared with the ordinary sampling method. It would be interesting to see how this method of bulk sampling compares with ordinary sampling.

In comparing the two methods, use can be made of the fact explained in a previous paragraph, that the standard deviation will be practically the same for 60 as for 360 samples. In a consignment of average variability, this standard deviation has been shown to be 2.25σ. Assuming a purity of 90 per cent for the 3,600 bags the error may be given as follows :—

Ordinary sampling method. 60 samples taken, i.e. $\sqrt{N.}$

$\sigma = 3$, S.D. $= 2.25 \times 2 = 6.75$

$$\text{S.E.} = 6.75/\sqrt{60} = .87$$

Bulk sampling method. 360 samples taken, i.e. 10 per cent of N, bulked, mixed and ten lots of 100 beans examined.

$$\text{S.E. of 360 samples} = 6.75 / \sqrt{360} = .355$$
$$\text{E of 10 samples} = 3.00 / \sqrt{10}$$

$$\text{multiplied by the correction } \sqrt{\frac{360 - 10}{360 - 1}}$$
$$\text{i.e. } .95 \times .987 = .925$$
$$\text{Total error} = 1.280$$

In this case, the error of the bulk sampling method was half as much again as that of the ordinary sampling method. It can be shown, by calculation, that 30 lots of 100 beans would have to be examined before the error of the mean purity would be as low as the ordinary sampling method. Obviously it is quicker to take 60 samples (6,000 beans) and examine them all, than to take 360 samples (36,000 beans) and examine 30 lots (3,000 beans).

As stated previously, one of the greatest objections to bulk sampling is the loss of data from which to guage the variability in quality. More than 20 to 100 samples add little to the accuracy of the figure for mean purity, and the only rational object of taking additional samples is to increase the chance of detecting bags containing inferior quality. When the samples are bulked before examination, this chance is lost, and, consequently, the additional samples serve no useful purpose. Bulking the samples precludes both an estimation of the variability in quality and also the detection of bags containing inferior quality cacao.

Special uses of Bulk Sampling.

Bulk sampling, however, has its uses, especially for the examination of consignments of poor quality and composed of bags of many different qualities. In such consignments, the error due to the poor and variable quality may be large, so that the additional error from bulking is not serious. In some cases great accuracy is not required, or the lower cost of examining only a few samples more than compensates for the loss in accuracy. The method is also useful for gaining accurate information on the quality of a large number of consignments, because, although the error for any single consignment may sometimes be large, the errors of the mean figures for all the consignments are small, because the plus and minus errors counterbalance. A method of bulk sampling is now in use for inspection of cacao at Gold Coast ports.

METHODS OF SAMPLING.

In devising a suitable method for the examination of cacao, the main questions are how many samples to examine, what size of sample to take, and whether to bulk the samples or examine each individually. The answers depend on the characteristics of the cacao to be examined—mean purity, size, and variability in quality

—and on the degree of accuracy required in the estimate made—of mean purity, and percentage of each defect. No one method is likely to be suited to every lot of cacao. It is clearly a waste of time and effort, however, to record the mean purity of bad cacao accurately, and in the examples that follow no consideration is given to cacao below 90 per cent purity.

Cacao of Uniform Quality.

From homogeneous cacao a sample of five to 20 beans will give the mean purity within + 1 and − 1 for cacao of from 98 per cent to 90 per cent mean purity, irrespective of the position from which the sample or samples are drawn and of the size of the consignment. In practice, however, it is not possible to render a large consignment of cacao homogeneous, and, even if thorough mixing is possible in the case of a small sample, it is desirable that the sampling figures should supply evidence of homogeneity, so that the errors to which they are liable may be estimated. For these reasons it is best to take samples of 100 beans at random from various parts of the mass of cacao and examine each sample individually.

Inspection for Cacao Producers' Co-operative Societies.

To take a concrete case. 100 bags of cacao belonging to a co-operative society were emptied on to drying mats and thoroughly mixed by the process of emptying and by subsequent shovelling. (In emptying the cacao, three bags were observed to contain cacao which differed markedly in appearance from the remainder and these were excluded for sale separately). The cacao was rebagged and 20 samples taken, each from a separate bag at random, giving the following mean purities on cutting:—97, 96, 99, 98, 94, 100, 98, 99, 99, 98, 96, 97, 97, 98, 97, 96, 98, 97, 96, 97. Analysis of these figures, as in Table XXVI, gives the following figures:—mean purity 97.25, standard deviation 1.89, standard deviation for homogeneous cacao 1.62, index of variability 1.17σ, standard error $\pm.42$. In view of the low index of variability, there is evidence that the cacao had been thoroughly mixed and that it was homogeneous. The most likely value for the true mean purity of the consignment is 97.25. The odds are 5 to 1 against the purity being less than 96.83 (= 97.25 − 0.42), and over 100 to 1 against it being less than 95.65 (= 97.25 − 0.42 x 3). In practice, there would be no need to make these calculations in the case cited, because it is sufficient to know that the true mean purity is unlikely to be below a specified percentage such as 95 per cent or 93 per cent. Inspection of the sampling figures shows that no sample is less than 90 per cent, the lowest being 94 per cent, so that it is extremely unlikely that the mean purity will be less than 95 per cent. The method of calculation, however, can be useful in doubtful cases.

How many cacao beans to cut and examine depends on the degree of accuracy required. When it is necessary to decide only that the cacao is above a specified percentage—95 per cent or 93

per cent—ten samples of 100 beans may be adequate, and in borderline cases, twenty samples. A safer number for all cases, however, is 20 samples. The procedure recommended is as follows :—after thorough mixing, take 20 samples (each of 100 beans)at random cut the beans, record the defects, and inspect the figures. If the mean is 95 per cent or over, and no sample is below 90 per cent, the mean figures may be accepted as satisfactory. If the mean is between 95 per cent and 93 per cent or one sample is less than 90 per cent, calculate the standard deviation (Table XXVI), divide by the square root of 20 and make use of Table XXII ; if still doubtful, take another set of 20 samples, and again make use of Table XXII.

An inspector may not always be present to see the 100 bag consignment made up. The mixing and rebagging may have been supervised by a trustworthy assistant inspector. In this case the inspector may wish to determine, in addition to the mean purity and the percentage of defects, whether the consignment has been properly made up, and the cacao, homogeneous. The method recommended is the same as in the previous paragraph, with the additional calculation of the index of variability when use can be made of Table VI. If the consignment contains over 100 bags, it is best to take samples equal to the square root of the number of bags, the additional samples being advisable because thorough mixing becomes more difficult as the size of the consignment is increased.

Cacao of Variable Quality.

It has been shown that as the quality of the cacao becomes more variable, so the sampling figures become less accurate, unless very many samples be taken. In sampling cacao of variable quality, it is essential to know, first of all, the object of the examination. In Europe, sampling is done in order to estimate the quality of the cacao in the consignment, not with a view to improving its quality but to finding out what it is. The object of inspection on the Gold Coast, however, is primarily to encourage the preparation of consignments of uniformly high quality ; consequently the methods of sampling employed provide for a thorough inspection of consignments of good quality, and for a much less thorough inspection of consignments of poor quality. The methods adopted locally will be described later, but, for the moment, attention will be confined to gauging the quality of a consignment of a quality unknown as regards both purity and variability.

The error to which sampling figures are liable may be divided into two types : those that depend on the number of bags in a consignment of cacao and those that are independent of the number of bags. The latter are errors concerned with purity and variability. The standard error is about ± 1 when 50 samples are taken from cacao of 90 per cent mean purity and of average variability in quality. If the mean purity is higher, fewer samples are

necessary (e.g. 28 samples for 95 per cent purity) and if the mean purity is less, a greater number of samples is necessary (e.g. 70 samples for 85 per cent purity, and 90 samples for 80 per cent). If the quality of the cacao is less variable, fewer samples are necessary (e.g. ten for uniform quality) and if the quality is more variable, a greater number of samples is necessary (e.g. 250 samples for very variable cacao). It seems fair, however, to take 50 samples as reasonable basis.

The errors which are dependent on the number of bags in the consignment of cacao include those that are due to variability between bags and those that are liable to occur on account of the possible presence of a few bags of very bad cacao. It is convenient to tabulate these.

TABLE XXV.

NUMBER OF SAMPLES FOR SAME LEVELS OF ACCURACY.

Number of bags.	100	250	500	1,000	2,500	5,000	10,000 bags
Variability between bags only. (Table XXI.) $\frac{N}{K(N-1)+1}$	34	42	46	48	49	49	50
	41	54	61	65	67	68	69
Odds of 4 to 1 against failing to detect the presence of 1 per cent bags containing inferior quality cacao	50	59	65	66	68	69	69
Equal chance of detecting, or failing to detect, n bags containing inferior quality cacao.	10	25	50	100	250	500	1,000
	2	5	10	20	50	100	200

From these figures it would appear that 50 to 70 samples from consignments ranging from 100 to 10,000 tons would give equally accurate results in average consignments. A range of 35 to 50 samples would give slightly less accurate results.

But, although one can calculate how many samples to take for equal accuracy from average consignments, it is quite impossible to say how many to take from any particular consignment. The number may be 10, or 500, depending partly on the purity but mainly on the variability. The only solution is to take a reasonable number of samples, and to make deductions from the results of the analyses.

In the example given in Table I, 40 samples were taken from 1,600 bags, and each sample was examined individually. A glance at the figures shows that the consignment was of fairly good quality with an estimated mean purity of 96.1 per cent, and that only two

samples were less than 90 per cent. The index of variability is 1.334σ, showing that there is no reason to believe that the consignment is not uniform in quality. The standard error is ± 0.425. 96.1 per cent exceeds 95.0 per cent by 1.1, which divided by .425 gives 2.6; hence according to Table XXII the true mean is almost certainly not less than 95 per cent. No bag of inferior quality cacao was detected in sampling. According to Table XI the odds are 4 to 1 against the consignment containing 1.8 per cent bags of inferior quality, or 29 bags, and 2 to 1 against it containing eight such bags. A consignment of this size would, on the average, contain six such bags, but as this particular consignment bears evidence of careful preparation, we may be reasonably certain that it contains no bags of inferior quality.

It is interesting to note that if the sample had been bulked, we should have had a much less comprehensive knowledge of the contents of this consignment. The estimate of the mean would not have differed greatly from 96.1 per cent, but there would have been no information as to the variability of the quality or as to the possible presence of inferior bags. Mixing the original samples into a bulk sample also destroys their value for estimating the degree of confidence that can be placed in the results of the examination.

Inspection at Ports.

As previously stated, inspection of shipments of cacao from Gold Coast ports has consisted in examining separately a number of samples equal to the square root of the number of bags. It is doubtful if so accurate a method is justified. Inspection of the cacao does not improve its quality Also, for the same degree of accuracy, it is necessary to examine many more samples from consignments that are variable and poor in quality, whereas those consignments are more worthy of attention that are uniform and good in quality. For these reasons the bulk sample method is now in use for ordinary inspection, and the time and labour so saved can be expended on a more detailed examination of consignments of high quality.

Ordinary Inspection of Shipments at Ports.

The present method is to bulk samples from the square root of the number of bags, mix the samples well, and examine 500 beans in five lots of 100 beans. The additional standard error due to bulking can be found in column 2 of Table XXIII; it is ± 0.97 for cacao of 95 per cent purity, and ± 1.60 for 85 per cent purity. According to Table XIII, the standard error of the original samples before bulking may be as low as ± 0.42 or as high as ± 3.33, but it may be still higher for consignments of very variable and poor quality. On the whole the total standard error may range from ± 1.5 to ± 5.0. This does not mean that the figures will always be inaccurate to this extent, but that they are liable to be so. The figure for mean purity is accurate enough to give a fair idea of

the quality of the consignment, and the mean figures from all consignments shipped are quite accurate for the purpose of furnishing the Department of Agriculture with estimates of the percentage defects in consignments shipped from each port each month. In fact, the main use of the port inspection at present is to record the quality of cacao exported.

Inspection of Superior Shipments at Ports.

Thorough inspection of bagged shipments of unknown quality is a formidable, if not an impracticable, task. The possible presence of a few bags containing inferior cacao rules out all methods of sampling other than taking a sample from every bag and examining it separately. If, however, the consignment is inspected before bagging or during re-bagging, the inspector has an opportunity of examining the cacao by eye and by small samples here and there throughout the heap. When the cacao is found to be of high quality throughout, the inspector can arrange for the bagging to be supervised, and the bags sealed ; he need then have no fear that the Government hall-mark of purity might be affixed to any bags that contained inferior quality cacao.

PERSONAL AND AVOIDABLE ERRORS.

Avoidable errors have been discussed by W. H. Beckett in Paper No. VII in the 1927 Year-Book. Briefly, personal errors from wrong counts of beans, and mistakes in recording and in arithmetic, are rare. Mechanical errors have been eliminated by the use of the standard sampling tools. There remain only those personal errors that depend on the judgment of the recorder.

The following definitions of defective cacao beans are taken from an unpublished paper by A. B. Culham (Paper No. XII in Bull. 20 Dept. of Agric., Gold Coast) :—

Mouldy.—When the bean contains moulds that are apparent to the naked eye.

Slaty.—When the interior of the bean is of a uniform slate colour.

Weevilly.—When the interior shows evidence of weevil attack.

Germinated.—When the testa of the bean is pierced as a result of germination.

Other.—When the cotyledons are absent or nearly so. Also pieces of placenta, shell and foreign matter, about the size of a cacao bean.

One person may see moulds, or evidence of weevil attack, that another person fails to observe. A slaty bean may not appear to be slaty to some observers. Errors of this description cannot be eliminated, but they can be kept at a minimum by standardisation. The above defects are fairly distinctive, but the classification of under-fermented beans presents a real difficulty, which is being met

locally by the preparation of a colour plate showing cacao beans in a gradation of colours from slate colour to purple and brown. A full discussion of this aspect of sampling is beyond the scope of this paper.

SUMMARY OF CONCLUSIONS.

Shipments of local cacao are rarely uniform, and often very variable, in quality.

Out of 100 consignments examined, 18 were uniform in quality, 30 slightly variable, 32 variable, and 20 very variable in quality. The index of variability ranged from 1.01σ to 4.88σ. Consignments ranging from 20 tons to 250 tons were equally variable. The mean index of variability was 2.25σ.

Variation between bags was twice as great as variation within. The mean index of variability was 2.8σ between bags, and 1.4σ within bags.

Lack of uniformity within bags was sometimes considerable.

No method of sampling other than testing every bag can guarantee to detect the occasional bag that contains bad quality cacao.

The chances of failure to detect the presence of a certain proportion of such bags can be calculated.

There is no practicable method of sampling that can give a reliable estimate of the mean purity of each bag sampled. A single sample of 100 beans taken from cacao that is uniform in quality will often not be of the same purity as the cacao.

A single sample of 100 beans taken from an ordinary bag of cacao will often give a false impression of the contents.

If a sample of 100 beans is taken from cacao that has been thoroughly mixed and it is below 90 per cent purity, there is strong evidence that the mean purity of the cacao is less than 95 per cent.

If ten samples are taken and one of these samples is below 90 per cent, there is a good indication that the mean purity of the cacao is less than 95 per cent.

The variability of a consignment greatly reduces the precision of the sampling figures. The number of samples required for equal accuracy for the three quality classes 'uniform,' 'variable,' and 'very variable' is in the proportion of 1 : 5 : 25.

The estimate of the mean purity is more accurate when the mean purity is high than when it is low.

Increasing the number of samples improves the precision of the sampling figures, but the improvement lessens progressively as the number of samples is increased.

In estimating the mean purity, 20 to 100 samples are adequate for normal needs, the number depending on the variability and purity of the consignment.

The chances that the true mean purity may be less than a specified purity may be calculated from the sampling figures by using Table XXII.

Bulk sampling is usually less accurate than examining each sample separately.

Bulking destroys the value of the samples for estimating the degree of confidence that can be placed in the results of the examination and also for detecting the presence of bags containing inferior quality cacao.

In the case of a small consignment of good quality, the method recommended is, after thoroughly mixing, to take twenty 100 bean samples at random and examine each sample separately Calculation of the mean purity, and inspection of the figures may serve to show that the consignment is uniform in quality and of the required purity. In border-line cases the standard error can be calculated, and critical tests applied.

In the case of a consignment of low purity, the method recommended is bulk sampling.

In the case of a large consignment, which is believed to be of good quality, the method recommended is to take and examine a sample from every bag, or, alternatively, to turn out the cacao into heaps, when inspection by eye may be supplemented by samples taken throughout the heaps and examined separately.

APPENDIX.

TABLE XXVI.

Calculation of Variability in a Consignment of Cacao.

Mean purity. %	From last column of Table I.	Samples (Frequency).	Frequency × Deviation.	Frequency × (Deviation)^2.
100	1	1	4	16
99	1 1 1 1 1 1	6	18	54
98	1 1 1 1 1 1 1 1	8	16	32
97	1 1 1 1 1 1 1	7	7	7
96	1 1 1	3	+45	—
95	1 1 1 1	4	4	4
94	1 1 1 1 1	5	10	20
93	1 1 1	3	9	27
92	1	1	4	16
91		—	—	—
90		—	—	—
89	1	1	7	49
88	1	1	8	64
		40	—42	289

	+ 3	
Divide by 40	+ 0.075	7.225
Subtract correction for mean	... $(0.075)^2$	.0056
		7.2194
Take square root	=	2.687
	=	Estimate of S.D.

Working mean 96.00
Correction + 0.075
Estimate of Mean purity 96.075%

From Plate II $\sqrt{\frac{96.075\ (100 - 96.075)}{100}} = 1.942 = \sigma$ for homogeneous distribution with mean purity 96.075

Estimate of Standard Deviation divided by σ $= \frac{2.687}{1.942} = 1.384$

Index of variability $= 1.384\sigma$

Standard error equals Estimate of Standard Deviation divided by Square root of Number of Samples.

$$= \frac{2.687}{\sqrt{40}} = \pm 0.425.$$

TABLE XXVII.

ANALYSIS OF VARIATION 'BETWEEN BAGS' AND 'WITHIN BAGS.' EXAMPLE TO SHOW METHOD OF WORKING.

Bag No.	Percentage purity Sample No. 1 x'	Sample No. 2 x''	Between bags. $x'+x''$	$\frac{x'+x''}{2}$	$\left(\frac{x'+x''}{2}-\bar{x}\right)$	$\left(\frac{x'+x''-\bar{x}}{2}\right)^2$	Within bags. $x'-x''$	$\frac{x'-x''}{2}$	$\left(\frac{x'-x''}{2}\right)^2$
1	86	82	168	84	—	—	4	2	4
2	88	94	182	91	7	49	6	3	9
3	92	84	176	88	4	16	8	4	16
4	70	72	142	71	13	169	2	1	1
5	88	88	176	88	4	16	—	—	—
6	78	92	170	85	1	1	14	7	49
7	70	64	134	67	17	289	6	3	9
8	84	94	178	89	5	25	10	5	25
9	90	86	176	88	4	16	4	2	4
10	92	86	178	89	5	25	6	3	9
	838	842				606			126
	1,680 Divide by 20 = 84								
	$\bar{x}$ = 84								
	Degrees of freedom = 10 x 2 — 1 = 19								

$2 \times \text{Sum}\left(\frac{x'+x''}{2}-\bar{x}\right)^2 = 1{,}212$

Degrees of freedom = 10 — 1 = 9

$2 \times \text{Sum}\left(\frac{x'-x''}{2}\right)^2 = 252$

Degrees of freedom = 10 (2—1) = 10

	1	2	3	4	5
	Degrees of freedom.	Sum of squares.	Variance.	Standard Deviation.	S.D. / σ
Between bags ...	9	1,212	134.7	11.6	3.16
Within bags	10	252	25.2	5.0	1.36
Total ...	19	1,464	77.1	8.8	2.40

Mean purity = $\bar{x}$ = 84

$$\sigma = \sqrt{\frac{\bar{x}}{100} \times \frac{(100-\bar{x})}{100}} \times 100 = 3.67$$

In practice, use may be made of short methods recommended by W. H. Beckett on page 53 of Bull. 20, Dept. Agr., Gold Coast. Sum of squares between bags equals $\frac{\text{Sum}\,(x'+x'')^2 - N(2\bar{x})^2}{2}$ where N is the number of pairs of samples, and sum of squares within bags equals $\frac{\text{Sum}\,(x'-x'')^2}{2}$.

PAPER No. XI.

COST OF ESTABLISHING CACAO BY ASHANTI FARMERS.

By T. HUNTER.

The Gold Coast is unique in that its farmers have raised such a valuable industry as the cacao industry to its present state, resulting in good returns to the farmer at what appears to be a minimum of expense and trouble.

The fact that the production of local cacao is mostly in the hands of illiterate peasants has made any accurate attempt at farm costing impossible, because of the lack of accurate information. The small size of most of the farms prohibits any system of regular labour and general absence of reliable data has made enquiry very difficult.

The writer has been fortunate enough to know three farmers who have made a successful start on sound lines. By encouragement and guidance they have so managed their farms as to obtain information, which, although it cannot be taken as being conclusive, is an interesting indication of the approximate cost of establishing a cacao farm on the Gold Coast. The period of years covered by the investigation represents the initial stage in the development of a plantation, but it is certain that a continuation of this work would give much useful information.

The men who have been responsible for this experiment have not followed the usual haphazard methods of the typical Gold Coast peasant. In each case there has been a careful choice of site, efficient organisation and the employment of elementary scientific knowledge. Most important of all, each has adopted an efficient method of accountancy. The purpose of this paper is to analyse the financial statements of these three farms and to see what can be learned from them. The method of working, of land tenure, etc., is different in each case and for that reason each farm has been considered separately.

FARM No. 1 DEUM COLE PLANTATION, ADJUMAMU, 28 MILES WEST OF KUMASI ON THE BIBIANI ROAD.

The owner of this farm is an ex-Assistant Overseer of the Department of Agriculture, in which he served for many years. He is well known to the writer and in addition to being an educated

man, is intelligent and painstaking. He has been watched with great care since he started his plantation, and his system of book-keeping is exemplary. His knowledge of accountancy is most unexpected and throughout his books one observes the logic and consistency of a clear thinker and master of detail.

This farm was started in 1927 and is situated in the dense forest area near the Offin River. The soil is a deep red loam, well-drained and typical of good cacao soil.

Although the owner has an option over 100 acres of forest, of this total only 28 acres have as yet been brought into cacao cultivation. The trees have been planted, and looked after according to the best principles of cacao farming, and, unlike the average cacao farm, shade trees have been supplied by the cultivator.

The agreement under which the land was obtained does not require any rent until after the fourth year, when the lessee will be required to pay £25 per annum, no matter what proportion of the land is cultivated. For this reason the capital expenditure up to date does not include any payment for the land.

The following financial statements have been built up from the owner's books. Since he started work in 1927, he has kept a diary into which he has entered every detail. He has also a labour book and a ledger. Included in his expenditure are his own maintenance and that of his family. No detail seems to have been small enough to escape his notice—the statement is therefore a complete one.

FARM No. 1.

Financial Statement for the Period September, 1927 to December, 1930.

(28 acres planted in cacao.)

Expenditure.	Amount.	Revenue.	Amount.
1927–28.	£ s. d.	1927–28.	£ s. d.
To clearing, lining, and planting cacao and catch crops on *11 acres* and maintenance	42 13 2	To sale of corn produced on cacao farm	30 5 6
To cost of transport	9 9 3	To balance due capital account ...	107 16 8
To cost of tools purchased ...	2 7 5		
To cost of harvesting crops ...	2 11 5		
To cost of miscellaneous expenses including £5 cost of demarcating land	20 9 8		
To cost of house for self and family	26 6 1		
To cost of clothing for self and family and household furniture	17 10 4		
To self and family maintenance	16 14 10		
	£138 2 2		£138 2 2

FARM No. 1—*continued.*

Expenditure.	Amount.	Revenue.	Amount.
1928–29.	£ s. d.	1928–29	£ s. d.
Capital Account	107 16 8	To sale of corn produced on cacao farm	29 11 3
To cost of clearing, lining, and planting cacao and catch crops on *17 acres* and maintenance of same	44 14 1	To sale of plantain, etc.	15 11 0
To cost of transport	3 1 10		
To tools purchased	2 0 3		
To cost of harvesting crops ...	6 7 3	To balance due capital account ...	160 5 7
To cost of miscellaneous expenditure	8 10 1		
To cost of clothing self and family, and household furniture	13 6 5		
To cost of self and family maintenance	19 11 3		
	£205 7 10		£205 7 10
1929–30.		1929–30.	
Capital Account	160 5 7	Sale of catch crops	42 7 1
To cost of cultivation and harvesting crops	36 19 8	2 Loads of cacao at 10s.	1 0 0
Self and family maintenance	35 10 0	To balance due capital	189 8 2
	£232 15 3		£232 15 3

FARM No. 2 AT BUA RIVER 51 MILES NORTH-WEST OF KUMASI.

This farm has been established by a well-trained business man who gave up business and started farming as an occupation. Although not trained in agriculture he has shown considerable business acumen ; in addition he has taken full advantage of any advice given him. During his first year's working he employed a suitable headman, and for the more technical work of lining and planting the farm, he employed an ex-Learner of the Department of Agriculture. Now, he does all the work himself assisted by labourers.

This farm was started in 1926 and is situated in a good forest area on rising ground which allows of good drainage. The soil is a deep red loam but of a rather heavier type than in farm No. 1. It appears to be typical of a good cacao soil in the district.

The land has been obtained, and is rented under the usual Ashanti Native Law, i.e. by assessing rental at the rate of 1d. per fruiting tree. Payment usually starts at the sixth year of working.

Accounts showing all expenditure and income have been kept as in the following statement. Owing to financial difficulties, very little was done during 1929–30, therefore no statement is included for that year.

FARM No. 2.

Financial Statement for the Period 1926–1929.

(45 acres planted in cacao.)

Expenditure.	Amount.	Revenue.	Amount.
1926–27.	£ s. d.		£ s. d.
To cost in connection with obtaining land, demarcation, preparing agreement, and transport in connection with same	12 1 6	Capital	165 17 6
To cost of preparing nursery and purchase and sowing seeds	2 16 0		
To cost of clearing 45 acres	30 0 0		
To cost of further clearing, purchasing seeds and planting corn, plantains, cocoyams over 45 acres done by contract	15 9 0		
To cost of yams bought for planting over portion of area	13 9 0		
To cost of making hills and planting yams	5 5 0		
To cost lining, holing, planting and attending to cacao seedlings including expert supervision	15 17 0		
To cost of weeding 45 acres ...	6 0 0		
To cost of tools purchased ...	3 17 0		
To wages Headman	23 0 0		
To transport	5 13 0		
To miscellaneous expenses ...	2 10 0		
To maintenance of family and general expenses ...	30 0 0		
	£165 17 6		£165 17 6
1927–28.	£ s. d.		£ s. d.
Capital account	165 17 6	By sales realised from yams ...	33 6 0
To cost of building one compound house	72 13 0	By sales realised from corn ...	3 12 9
Wages for 5 labourers at £9 each per annum	45 0 0	To balance due capital	291 16 9
Hire of 6 lorries at £2 each ...	12 0 0		
To cost tools	0 18 0		
Amount of cash for self subsistence	12 0 0		
Miscellaneous personal expenditure	20 7 0		
	£328 15 6		£328 15 6

FARM NO. 2—*continued.*

Expenditure.	Amount.	Revenue.	Amount.
1928–29.	£ s. d.		£ s. d.
Capital account	291 16 9	By sales realised from yams ...	26 0 0
To cost of tools bought ...	1 15 0	By sales realised from plantains ...	18 0 0
To wages 5 labourers at £9 each per annum	45 0 0	By sales realised from corn ...	3 9 0
To transport on 53 bags dried plantains	2 19 2	By sales realised from coco-yams ...	6 5 3
To transport	6 0 0	To balance due capital	323 18 8
Amount of cash for self subsistence	12 0 0		
Miscellaneous personal expenditure	18 2 0		
	£377 12 11		£377 12 11

FARM No. 3 AT BECHEM, 39 MILES NORTH OF KUMASI.

This farm was established by an ex-Learner of the Department of Agriculture. Having little capital he followed very closely the native methods of establishing a farm under such circumstances. He has only employed labour to help with the heavier stages and has maintained himself by working at other business when not employed on his cacao farm.

FINANCIAL STATEMENT FOR THE PERIOD 1927-1929.

(11 acres planted in cacao.)

Expenditure.	Amount.	Income.	Amount.
1927 (*First Year*).	£ s. d.		£ s. d.
Clearing 6 acres forest ...	3 0 0	Sale of surplus corn after meeting family requirements	1 10 0
Burning and further clearing done without cash by self and family	—	To balance ...	7 10 0
Plants and suckers of all kinds, obtained free	—		
Planting catch crops, plantains, coco-yams done by self and family	—		
1929 (*Second Year*).			
Clearing 5 acres forest ...	2 0 0		
Burning and further clearing done by self and family ...	—		
Plants and suckers of all kinds, obtained free	—		
Planting catch crops, plantains cocoyams and planting done by self without cost ...	—		
1st weeding 6 acres	1 10 0		
2nd weeding 6 acres	1 10 0		
1st weeding 5 acres	1 0 0		
	£9 0 0		£9 0 0

This case illustrates how a man with family help can establish a farm with very little capital—it being quite a common practice for families to help in this way. The land being family land, no rent is required. The operator has worked hard, and the farm is well laid out and looks very promising. It further serves as an excellent demonstration to farmers in the district.

METHODS OF WORKING FARMS.

In all three cases the methods of working have to a large extent followed ordinary native practices, but with more thoughtful planning and with, consequently, better results.

Labour.

Labour has been fairly easily obtained and work has been done by contract and day labour ; the rates for the former being £13 per year at farm No. 1 and £9 at farm No. 2. Food and lodging are free at both places so that these labourers are really better off financially than labourers in towns paid higher cash rates.

Clearing.

Clearing in all cases consisted of removing the undergrowth and smaller trees by cutting and burning. None of the larger forest trees was felled and very little stumping was carried out at the time of clearing, other than where it could be done easily to make way for planting. Further ground clearing has been done in connection with the cultivation of catch crops.

Planting.

The farms were lined off and holes dug for the cacao before the catch crops were planted, the distance allowed being 12′ x 12′. The fact that planting was done in a proper manner has no doubt been largely responsible for the healthy and even appearance of the young trees. Under ordinary native methods, a small hole is scooped out with a cutlass and the young cacao plants squeezed into it ; this naturally does not enable the young plant to establish itself quickly.

Cacao nurseries were established at the time of commencing operations and the plants were planted in the field the following June.

Catch Crops.

Catch crops were planted a few months before the cacao. The crops planted varied with the individual requirements, but in all cases two crops of corn were grown the first year and a good shade cover of plantains and cocoyams established. Rain trees were planted as permanent shade. These and the remaining larger forest trees should provide all the protection required in the future.

Cultivation.

In conjunction with the cultivation given to food crops the cacao plants have received a considerable amount of attention and are in a much healthier state than are the plants seen on an average native farm. The catch crops have proved remunerative up to the present and have been most efficient as cover crops for the young cacao. The cocoyams will be removed this season but the plantains will remain for another year or so and continue to bring in revenue.

A little more stumping would probably have been better in the first instance, and, in future cases, no doubt, economies could be effected to cover the cost of this work. An estimate of £1 per acre would be sufficient to cover this.

Each of these farmers intends planting more food crops, on a rotation basis, on land apart from the cacao farm. These crops will provide for their own and their families' needs and the surplus will be marketed, thereby keeping down capital costs of cacao to a minimum.

CONCLUSIONS.

The financial statements given above show that there is, in Ashanti, at least one farmer who will in future have reliable data concerning production costs.

A definite indication has been given that the educated man is being drawn to the land. This in itself is a point of deep significance.

PAPER No. XII.

A NOTE ON THE SUN-DRYING OF CACAO.

By H. A. DADE.

In a previous publication reference was made to the difficulty of expeditious sun-drying of cacao owing to the type of weather which prevails during the cropping season. An example was given of a batch of cacao the drying of which occupied 14 days owing to frequent rain. The result was that 30 per cent of the cacao became commercially mouldy by the time drying was complete.

It is however not only rain which delays drying at this time of the year. The duration of sunshine is another important limiting factor. In the rain forest zone, in which the cacao areas are situated, the sky is overcast for a large part of most days, and the duration of sunshine is remarkably short. This condition, combined with that of the high relative humidity which is also typical of the forest region, is responsible, quite apart from the further delays caused by rain, for very slow drying.

An interesting example is provided in the Table which shows the duration of sunshine at Anyinam, a typical rain forest station, during the season 1929. This was recorded by means of a Jordan sunshine recorder, and includes all sunshine, of which a large part was of very low intensity and of little use for drying. Days on which rain fell are also indicated, and it will be seen that the duration of sunshine was by no means limited by wet spells alone.

The same difficulty is of course experienced in agricultural stations. In 1930, cacao set out to dry at Aburi at the ends of November and December required 13 and 14 days' drying. These batches showed over 25 per cent of mouldy beans.

While the farmer is responsible for many defects in his produce, it is evident that some of the conditions of preparation are not within his control. There is not the slightest doubt that the difficulties attending sun-drying are largely responsible for the mouldy component which unfortunately is characteristic of Gold Coast cacao.

Any efficient form of artificial drying is beyond the means of the individual small holder, and we are again reminded of the possibilities of co-operation as a solution of the problem in this, as in so many other, cases.

ANYINAM FIELD STATION—1929 SEASON—DURATION OF SUNLIGHT IN HOURS.

(Rain fell on days marked *.)

Day of Month.	July.	August.	September.	October.	November.	December.
1	1.75*	1.0	2.0	0.5	4.25	6.5
2	0.5*	3.0	0.25*	4.25*	3.5*	7.0
3	0.0*	5.75	3.75	3.5*	5.0*	6.25
4	2.25	2.25	3.0*	3.0	0.0*	7.25
5	0.75*	0.25	2.5	4.5*	6.25	7.25
6	2.25*	0.0*	3.75	3.0*	6.75*	6.25
7	2.0	0.5*	1.25*	0.25*	2.5*	5.0*
8	2.75*	4.5	1.75*	3.75	6.0	1.25
9	4.5	4.75	2.0	4.5	2.75*	9.0
10	2.75	3.75	2.25	4.25*	4.0*	8.75
11	1.5	1.75	1.25	3.25	2.5*	7.0
12	1.25*	0.5	0.5	5.75*	3.75*	5.25
13	2.5*	1.25	2.25*	3.75*	4.75	8.75
14	2.5*	1.75	2.5	3.25	8.5	8.5
15	0.5	5.5	1.75*	4.0*	4.5	7.75
16	2.0*	5.0	3.0*	5.5*	2.75*	3.75
17	0.25*	0.0	0.0*	7.25*	3.75	8.0
18	0.25*	0.75*	0.5*	2.75*	5.5	8.25
19	3.5	0.25	2.5	2.0	3.75*	8.5
20	1.5*	2.0*	2.0*	2.0	5.75	7.75
21	2.5	1.0*	2.5	2.75	6.5*	6.0
22	1.25	0.0*	2.75*	1.5	4.75	5.25
23	5.5	0.0*	3.5	2.0	2.25*	7.25
24	4.0	0.5*	1.25*	3.75*	4.75*	7.5
25	2.25	0.75*	3.5*	3.5*	4.25*	5.5
26	0.75	0.5	0.25*	4.5	5.0*	4.5*
27	3.75	0.25*	1.25*	3.25	5.25	6.25
28	2.25	2.0*	2.5	2.25*	7.75	6.75
29	1.5	0.0	3.5	6.5	6.5	3.0
30	2.75	0.25*	1.5	4.25*	6.5	5.0*
31	0.5	0.0	—	3.0	—	6.5
Totals	61.75	49.75	62.25	108.5	140.0	202.5
Mean daily	1.99	1.61	2.08	3.5	4.67	6.53

PAPER No. XIII.

FURTHER OBSERVATIONS ON CACAO POD DISEASES IN THE GOLD COAST.

By H. A. DADE.

Preliminary detailed observations on cacao pod diseases in native farms in the Gold Coast were made in 1926. The results were sufficiently interesting to justify further investigations, more especially so because the data obtained in one season only are not enough to provide an accurate conception of the significance of pod disease. A clear conception can, in fact, only be obtained when data for many years can be reviewed. Such data are not yet available, but those which have been already collected provide information which it is considered should not be withheld pending a complete study.

Continuous and extended observations have been made in the Anyinam District—the area studied in 1926—since 1928. The system adopted in 1928 proved to be unsatisfactory, and the data collected in this season are of limited value. In 1929 and 1930 the original methods used in 1926 were reverted to, with the difference that some observations were extended to cover the whole crop instead of only the trunk crop. Three of the original 1926 plots were discarded, and three of the more typical retained, while four additional plots, in the neighbourhood of the villages of Moseaso and Osino, were selected and observed. The plots are all one-fifth of an acre in area, but in many of the tables in this paper, figures are given in the standard terms of crop per acre, because this gives a more direct impression to those familiar with cacao.

The system now in use will be continued in future years, and it is hoped that in time, results will enable us to forecast approximate incidence, loss, etc.

(In 1928 the system tested was a simplified one based on the random selection of twenty trees in each farm. It was supposed that by this means useful and wider information would be obtained with the minimum expenditure of labour, but results showed that the method was unsound. Subsequent consultation with Mr. W. H. Beckett, of the Division of Statistics and Surveys, led to a reversion to the original method. In 1929 and 1930 data are strictly comparable, and these also afford legitimate comparison with some of the 1926 and 1928 results.)

OBJECTS AND LIMITATIONS OF THE INVESTIGATIONS.

In order that the significance of the work described may be properly understood, it is necessary to state clearly its objects and limitations. The object is to obtain information relating to the economic aspects of cacao pod diseases as found in actual practice on native farms, under conditions of cultivation which are characterised by the persistent failure of the farmers to realise the essentials of orchard management as they are understood elsewhere, and which would be more correctly described as the almost complete neglect of cultivation. This attitude of the Gold Coast farmer is due not to want of intelligence, but to the peculiar local and probably temporary economic situation which makes it possible for him to obtain large profits with little effort—in fact, to extreme domestic prosperity. We are not here directly concerned with these considerations, but indirectly with their repercussions on the crop itself. Obviously, neglect of cultivation has a profound effect on the physiology of the host plant, which is correspondingly debilitated and short-lived, while irregular and infrequent harvesting has an equally important effect on the incidence and loss from pod disease.

It is obvious that conditions in native farms are very different from those on experiment stations, where proper methods of treatment and management are applied, and this fact indicates at once the special and different values of investigations carried on under each kind of condition. Investigation on experiment stations is always critical, while in conditions of native cultivation it is only sometimes critical. On the other hand, observations under conditions of actual farm practice provide us with information of definite value so far as the cacao trade is concerned. Field investigations show us the economic situation as it is, station experiments show us how the economic situation may be advantageously modified. The distinction is of course not really so sharp as this—the two types of work overlap to some extent. They are interdependent and complementary.

A good deal of the work described here, therefore, is not of the nature of critical physiological studies, but indicates the fluctuation of events which directly affect the market. In some cases, however, the data have a critical value, in others, the facts observed in the farm can be correlated with the results of critical studies performed on experiment stations.

One advantage of work on these farms is that the crop and the disease can be observed in what are practically natural conditions—i.e. with an almost complete freedom from the introduction of complicating factors produced by cultural operations.

GENERAL COMPARISON OF THE SEASONS.

From purely empirical observation in the large region of which Anyinam-Osino Districts is a representative part, the seasons to be compared—1926, 1928, 1929, 1930—may be classed roughly, so far as quality and quantity of crop are concerned, as follows :—

1926. Good. High production and low loss from disease.
1928. Average.
1929. Bad. Low production and high loss from disease.
1930. Average.

GENERAL STATISTICS OF PRODUCTION, INCIDENCE OF POD DISEASE AND LOSS.

The Tables Nos I–IV show statistics of production, incidence and loss in the various plots for, as far as possible, the years 1926, 1928, 1929 and 1930.

TABLE I.

PRODUCTION IN POUNDS OF DRY CACAO PER ACRE.

Plot.	Potential.			Actual.		
	1926.	1929.	1930.	1926.	1929.	1930.
1	1,540*	1,113	1,322	1,479*	780	1,078
2	1,440*	929	863	1,384*	874	747
5	1,420*	854	1,266	1,367*	647	1,107
7	—	731	587	—	644	564
8	—	577	799	—	447	699
9	—	1,101	739	—	955	687
10	—	1,882	1,383	—	1,530	1,261
Totals		7,187	6 959		5,877	6,143

*Probably under-estimated.

TABLE II.

INCIDENCE OF POD DISEASE, PER CENT OF TOTAL PODS PRODUCED.

Plot.	1926.	1929.	1930.
1	—	48.2	58.2
2	—	26.7	27.7
5	—	68.1	46.8
7	—	37.8	39.6
8	—	62.3	38.6
9	—	36.8	17.9
10	—	36.5	42.6
On totals ..	64*	42.8	41.9

*Estimated on large reapings throughout the season.

TABLE III.

INCIDENCE OF DISEASE, PER CENT OF TRUNK CROP ONLY.

Plot.	1926.	1928.	1929.	1930.
1	71.0	89.4	91.9	76.3
2	52.5	87.5	69.6	65.5
5	60.9	52.5	86.5	72.0
7	—	63.4	66.1	53.9
8	—	49.6	87.0	47.5
9	—	51.0	57.5	51.9
10	—	26.4	64.5	64.1
On totals ..	58.3	55.9	75.7	63.6

TABLE IV.

LOSS CAUSED BY DISEASE, PER CENT OF TOTAL POTENTIAL CROP

Plot.	1926.	1929.	1930.
1	—	27.7	19.0
2	—	6.3	13.5
5	—	24.8	12.3
7	—	11.5	4.0
8	—	22.0	12.5
9	—	13.4	7.0
10	—	19.8	8.7
On totals ..	4.1*	17.9	11.7

*Estimated on large reapings throughout the season.

These totalled data confirm in a general way the rough empirical classification of the seasons concerned. Their main interest however lies not in the totals, but in the fluctuating behaviour of the individual plots, which must now be examined.

Tables V and VI provide additional data for use in this examination, and reference should also be made to Table IX in the section on Cushion Canker.

TABLE V.

PERCENTAGE OF SOUND CACAO IN CROP UTILISED.

Plot.	1929.	1930.
1	71.6	49.0
2	66.1	80.4
5	47.7	59.1
7	70.8	51.5
8	48.5	67.1
9	72.9	83.3
10	78.6	57.1

TABLE VI.

PODS PER LB. OF DRY CACAO.*

Plot.	1929.	1930.
1	8.4	8.8
2	8.3	8.9
5	9.8	9.7
7	9.6	9.6
8	9.6	9.0
9	9.2	9.3
10	8.9	9.2

*Calculated from wet weight on a standard of 8 per cent water content.

ANNUAL FLUCTUATIONS IN PERIODICITY, PRODUCTION AND POD DISEASE.

The individual plot data demonstrate several characteristics of the effects of pod disease and the economics of native cultivation. These are shown graphically in the Plates I and II (the construction of the first series of graphs is explained in the accompanying legend). The other series shows the same data expressed as percentages of each reaping.

The first and most obvious impression conveyed by these diagrams is the relative infrequency and irregularity of reaping. The result of infrequent reaping is of course a high incidence of, and loss from, disease, because many pods become infected which would otherwise be reaped before this could occur, and because others which might be reaped in the early stages of infection actually become too rotten for use by the time they are collected. In some cases, a portion of the crop also becomes over-ripe, but the tendency is generally to reap a slightly under-ripe rather than an over-ripe crop. Two arguments are put forward by farmers in defence of their methods—(i) that the relative small saving of crop achieved by frequent reaping is outweighed by the extra expense on labour; (ii) that frequent reapings do not produce sufficient crop to make sufficiently large fermentation masses. These statements are probably true in the case of the usual very smallholdings. Under the existing system therefore these arguments appear to be sound. It is the system of small individual effort which is unsound and uneconomical in the present state of the trade, and the desirability of some form of communal effort is clearly indicated.

The next striking point of interest is the rather steady and consistent decline of incidence and loss as the season progresses. The greatest incidence and loss occur in the early reapings, and this is true whether regarded from the point of view of each reaping, or from that of the total annual crop.

Apart from the question of loss of crop, uneven distribution of incidence may have a distinct effect on the market product. There is a much larger proportion of cacao damaged by pod disease fungi in the early output, and such cacao is more susceptible to moulding, germination, and probably to some other defects. We might therefore expect to find some evidence of this effect in the market product. Examination of data obtained by inspection of exported cacao, however, does not reveal any clear or consistent indication of a change in quality during the season which might be correlated with the change in the disease situation. The incidence of defects in the exported produce is largely determined by the processes of preparation and by subsequent storage, to such an extent, in fact, that the effect of disease is masked.

ANNUAL DIFFERENCE IN BEHAVIOUR.

The graphs show a very distinct difference in the behaviour of the several plots in the two years under observation. The chief interest of this difference is that it is not, as we might expect it to be, consistent—plots in the same district exhibit opposite behaviour. For example, in Plot I, Anyinam, the 1930 crop is earlier and larger than in 1929, while in Plot 2, Anyinam, it is later and smaller. Similar contrasts are found in all of the three areas—Anyinam, Moseaso and Osino, and for all of the phenomena studied.

It is evident that the fluctuating annual behaviour of cacao is determined by local environmental as well as by meteorological conditions, and that the former are at least as equally important as the latter. A season which is " good " for one farm may be " bad " for another, even in its close neighbourhood. This fact is important because it shows that we cannot regard observations made on any one farm as definitely representative of conditions in a district.

(The system of forecasting employed by the Division of Statistics and Surveys in this Department is partly based on observations derived from a number of small plots throughout the cacao areas. In passing, it is therefore desirable to point out that the possibility of such phenomena as that described above was not overlooked by the officers concerned, when the system was devised and instituted. Due attention was paid to the problems of sampling which are involved.)

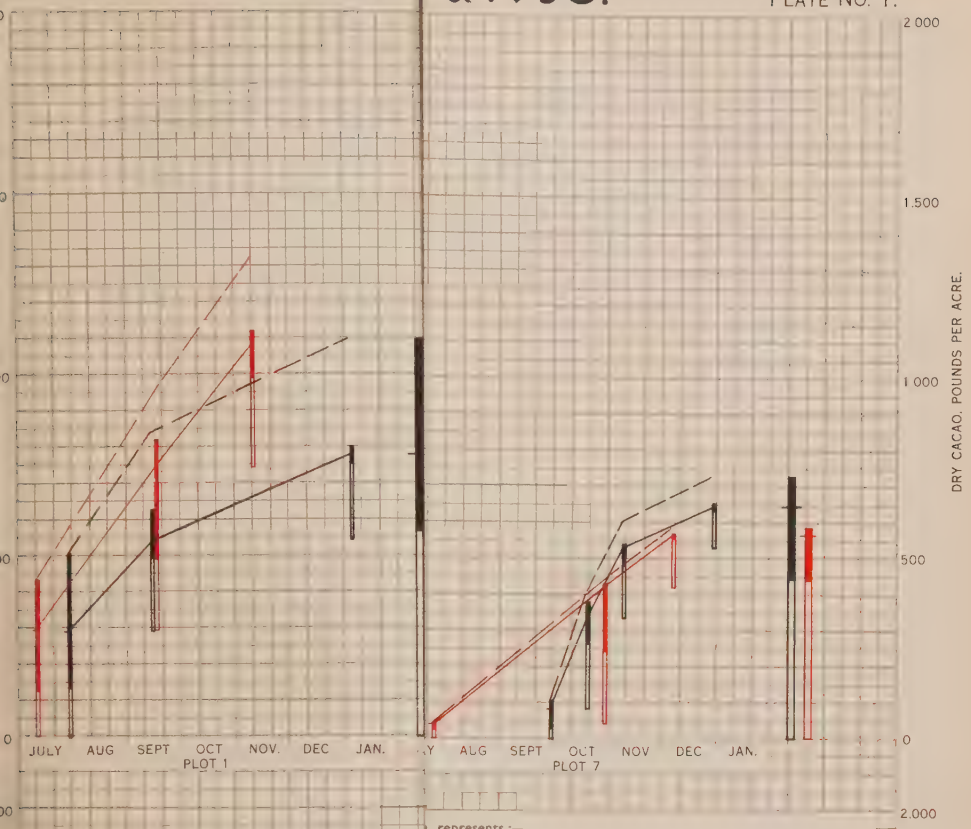
Tables I–IV above provide the available relevant information regarding the behaviour in each year of the plots under discussion, with the exception of periodicity, which is sufficiently well illustrated in the graphs.

We may summarise the results, in the following Table No. VII, by using plus or minus signs to indicate the nature of the behaviour of the crop in 1930 as compared with 1929. The plus sign indicates improvement—i.e. earlier and higher production, lower incidence

ANY? & 1930.

PLATE NO. 1.

SURVEY H.Q. ACCRA, 1931.



represents :—

PERIODICITY OF REAPING

INCIDENCE OF POD DISEASES

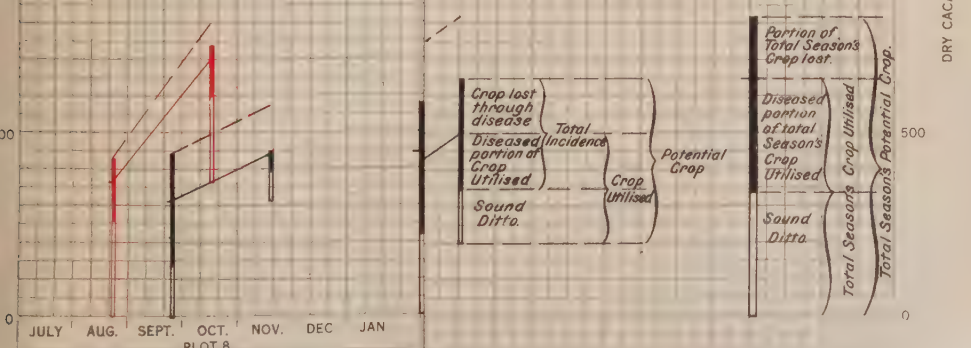
LOSS FROM POD DISEASES

COMPOSITION OF CROP

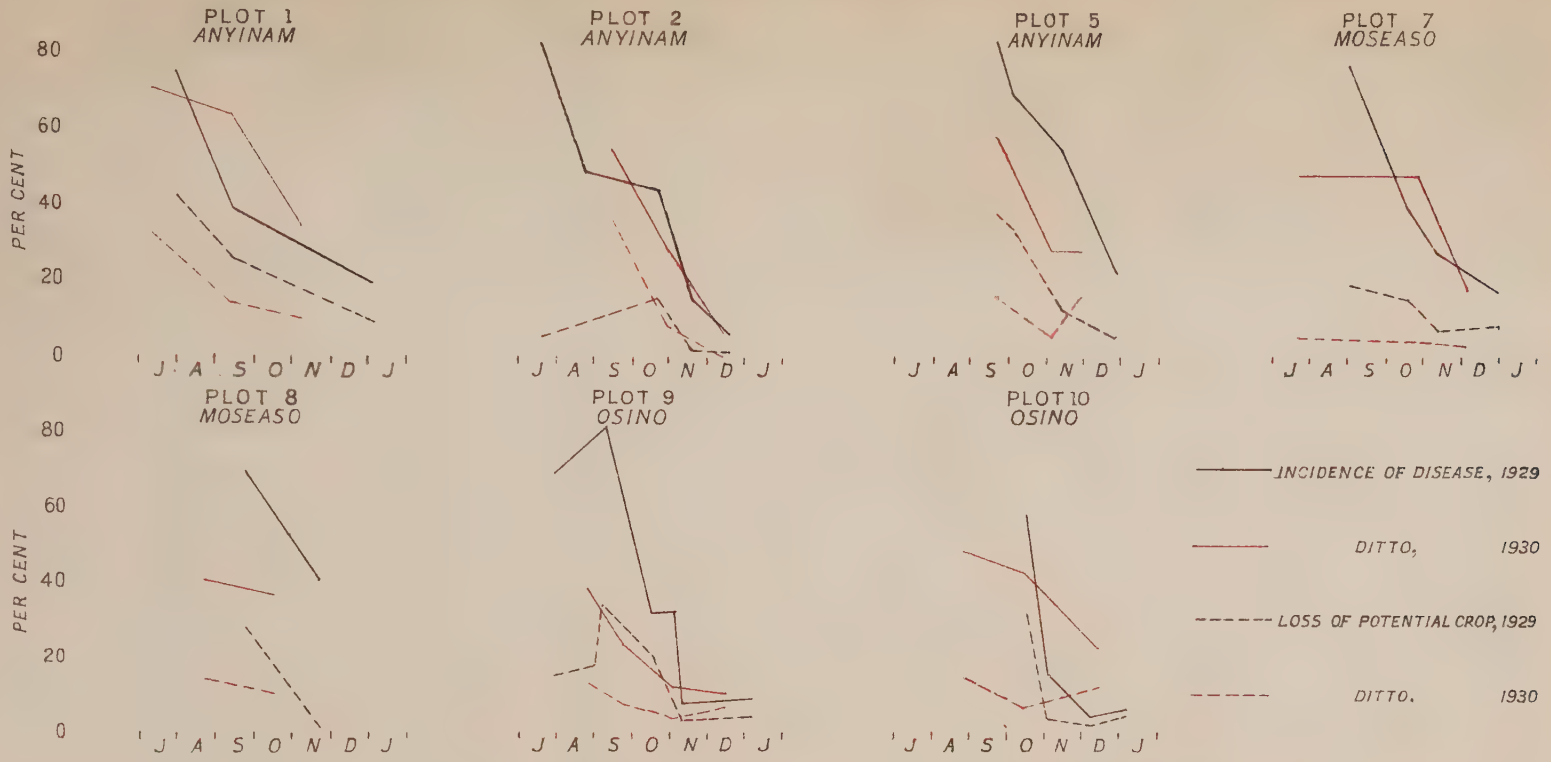
PRESSED IN TERMS OF DRY CACAO (8% WATER CONTENT) PER ACRE.
OLUMNS REPRESENT INDIVIDUAL REAPINGS: PORTIONS IN BLOCK COLOUR
NT COMPONENT FROM DISEASED PODS CONTINUOUS LINE CURVE IS
TE ACTUAL CROP: BROKEN LINE CURVE IS AGGREGATE POTENTIAL
DIFFERENCE REPRESENTS LOSS FROM DISEASE. PORTIONS OF COLUMNS
CTUAL CROP CURVE REPRESENT LOSS IN EACH REAPING
OLUMNS SHOW SAME DATA FOR COMPLETE SEASON'S CROP

(See Key Diagram below).

1929 CROP. BLACK 1930 CROP. RED.



INCIDENCE OF POD DISEASE AND LOSS OF CROP THROUGH DISEASE ON NATIVE CACAO FARMS AT ANYINAM FIELD STATION, SEASONS 1929 AND 1930.



SURVEY H.Q. ACCRA, 1931.

of disease and loss of crop, and higher percentage of sound cacao in the crop; the minus sign indicates the reverse condition. The '?' sign indicates no marked difference. In this table the factors of which the data are probably indicative are also shown.

TABLE VII.

Summarised Characteristics of Behaviour in Individual Plots.

Factors.	Rainfall regime.	Nutritive resources.	Vigour.	Resistance Micro-phenology.				Net result.
Plot.	Periodicity of fruiting.	Potential Crop.	Pods per lb.	Cushion Canker.	Loss.	Sound Crop.	Incidence of Pod Disease.	Actual Crop.
1	+	+	—	+	+	—	—	+
2	—	—	—	+	—	+	—	—
5	+	+	+	+	+	+	+	+
7	?	—	?	—	+	—	—	—
8	+	+	+	+	+	+	+	+
9	—	—	—	+	+	+	+	—
10	?	—	—	—	+	—	—	—

It will be seen that early production appears to be correlated with high production, that there is also some degree of correlation with the other phenomena, and that the net result of all, as reflected in the actual crop obtained, shows the same relation.

Surveying this net result, we find definitely opposite results in two of the three localities although all the plots which are in the same wide district, were subject to the same general climatic conditions, and those in each locality to the same local climatic conditions.

That these results are due to the combined effort of environmental and meteorological conditions can be the only explanation of what appears to be inconsistent behaviour. It is easy to understand how this may be so by considering a simple hypothetical case. Let us suppose that we have two neighbouring farms in different conditions of water relation—by which is meant the

supply, and conservation by protection of the supply, of water. One, A, has a water relation above the optimum, the other, B, has a water relation below the optimum. An unusually long and pronounced dry season would probably produce opposite effects on the two farms—it would result in a good season for A and a bad one for B. The reverse effect would ensue after a year in which the rains were more evenly distributed than is normal, and in which as sometimes happens, the dry season is short and not intense.

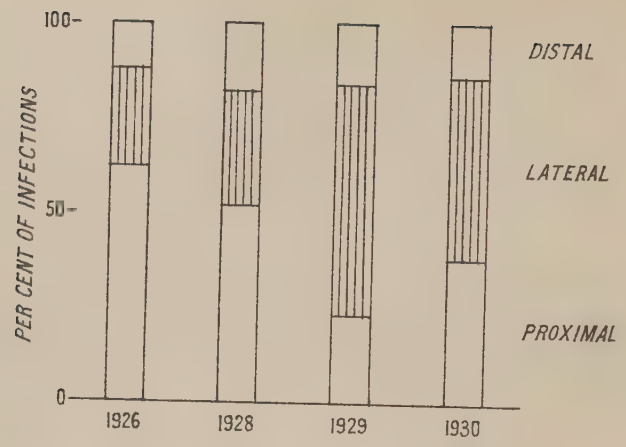
While the actual problem is by no means so simple as this, there is no doubt that the distribution of rainfall and the *harmattan* season particularly is of first importance in determining periodicity and magnitude of crop, and more or less indirectly the effect of disease. Careful investigations would no doubt produce very interesting and valuable results.

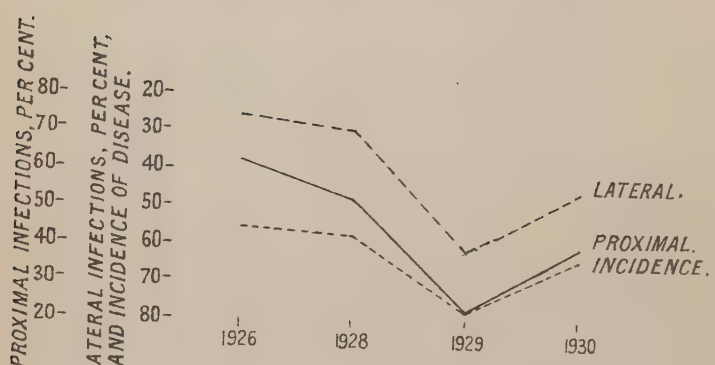
SITE OF INFECTION.

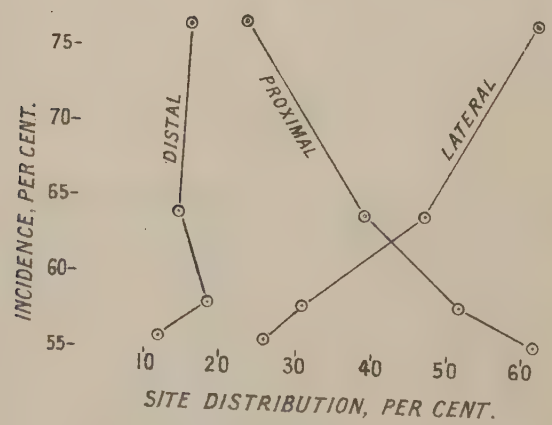
In the original description of the 1926 investigations an account was given of the distribution of infections of trunk crop according to the region of the pod in which they occurred. It was found that this distribution was remarkably similar in all the farms which were under observation, and it was suggested that it was determined by the morphological characteristics of the tree and pod.

The infections were classified as proximal, lateral and distal. Proximal infections were those which originated at the insertion of the peduncle, distal infections those which originated at the extreme tip of the pod, and the remainder, the lateral class, those which occurred between these points, on the sides of the pod. Observation showed that infection was promoted by the retention of drops of water in the annular depression around the peduncle, at points of contact of the pod with the trunk and with other pods, and at the not very efficient drip-point at the distal extremity, and also by contact with other diseased pods.

It was shown that some proportion of the proximal infections was due to cankered cushions, but at that time it was not possible to assess that proportion. In subsequent years a record of infections from cankered cushions has been kept, and it is now possible to separate these cases which are not correlated with morphological characters, and to make a closer examination of the data. It is also now possible roughly to assess the effect of canker in the 1926 data, and to compare these data with those of subsequent years. Figures are thus available for the seasons 1926, 1928, 1929 and 1930, and are shown in Table VIII ; the site distribution data of the last three years do not include infections due to canker, and the 1926 data have been adjusted by using the average incidence of canker infections in later years.







SITE OF INFECTION.

TABLE VIII.

Year.	Incidence of disease per cent of trunk crop.	Site. (Per cent of total infections).		
		Proximal.	Lateral.	Distal.
1926	55.7	61.8	26.2	12.0
1928	58.0	51.5	30.2	18.3
1929	76.8	23.0	61.4	15.6
1930	64.1	38.6	46.9	14.6

The diagrams in Plate III show (i) the site distribution in columns (ii) percentages of proximal, lateral and distal infections compared with the corresponding incidence of disease (iii) correlation between site distribution and incidence of disease.

The proportion of distal infections does not vary appreciably, but the proximal and lateral proportions fluctuate considerably, and show respectively a close negative and positive correlation with incidence of disease. The greater the incidence the greater the proportion of lateral, and the smaller the proportion of proximal, infections.

We know that incidence is largely determined by humidity, and we may assume that if the whole surface of a pod were uniformly exposed and covered with a film of moisture, the chance of infection would probably be equal for all parts of the surface, and the effect of morphology would be neutralised. This condition is approached more closely in a year of high humidity and incidence than in one of low humidity and incidence.

It seems probable, then, that the interaction of constant morphological and fluctuating "micro-climatic" factors is responsible for the variation from year to year in the site-distribution of infections. In view of the recent growth of attention to the importance of the "micro-climate" this phenomenon is not without interest.

CUSHION CANKER.

Canker is rarely of importance as a bark disease in the Gold Coast, but it has a great influence on the incidence of pod disease, and is therefore conveniently dealt with in a consideration of pod disease. Descriptions of cushion canker have appeared in previous publications (2,) (3).

The Tables Nos. IX and X, show canker statistics for the years 1928–1930.

TABLE IX.

PERCENTAGE OF TOTAL TRUNK CROP INFECTED FROM CANKERED CUSHIONS.

Plot.	1928.	1929.	1930.
1	10.6	17.7	9.3
2	12.4	12.0	3.7
5	6.8	7.9	3.8
7	15.4	4.4	6.4
8	0.7	7.0	4.9
9	8.4	3.9	3.3
10	2.8	5.4	5.9
On Totals ..	7.5	8.6	5.4

Cases of pod disease arising from cankered cushions are the result of the previous year's pod infections. We might therefore expect to find a high percentage of infections from cushions in the season following a year of high incidence.

We have a good example of a bad season in that of 1929, which was characterised by high incidence and loss. In Table IX, 1930 however we find a distinct decrease in infections due to canker. Similarly, although 1928 was not a bad season, we find an increase in 1929. The general average is, in fact, in agreement with the rough classification of the seasons shown at the beginning of this paper. Now these cases are not influenced by the external conditions which determine normal incidence, but are subject only to internal factors. We must therefore conclude that we have here a further example of the effect of the physiological condition of the tree—that the activity of the fungus in the bark is inhibited by the comparatively good condition of the tree in the more favourable conditions of 1930 and 1928. (cf. the section on Annual Fluctuations in Periodicity, etc., in which further reference to these phenomena is made).

Table X shows the very marked significance of canker in terms of percentage of the total number of infections of trunk crop.

TABLE X.

PERCENTAGE OF TOTAL INFECTIONS DUE TO CANKERED CUSHIONS.

Plot.	1928.	1929.	1930.
1	11.9	19.3	12.2
2	14.3	17.3	5.6
5	12.9	9.1	5.0
7	24.4	6.8	11.9
8	1.4	8.1	10.1
9	16.5	6.9	6.4
10	10.4	8.5	9.2
On totals ..	13.4	11.3	8.7

In previous notes on canker it was stated that cushions which become infected in one year transmit disease to the crop which they bear in the following year, and that the cushions are destroyed by the fungus in this second year and then cease bearing. These statements were based on careful field observations, but until now it has not been possible to produce statistical proof. Systematic records of cankered cushions have confirmed these statements, as indicated in the Table No. XI below.

TABLE XI.

CUSHIONS INFECTED IN 1928 WHICH TRANSMITTED INFECTION TO PODS BORNE ON THEM IN 1929, AND THEIR BEHAVIOUR IN 1930.

Plot.	Number of cushions infected 1928, transmitted infection 1929.	Behaviour of same cushions in 1930.		
		Produced no crop.	Produced crop and transmitted disease.	Produced sound crop.
1	77	75	—	2
2	23	22	—	1
5	31	31	—	—
7	8	7	1	—
8	38	38	—	—
9	13	13	—	—
10	11	11	—	—
Totals	201	197	1	3

Comparing these figures with those of Table IX, the effect of canker on the crop would appear to be very serious and progressive, for we see, in three successive years, the destruction of cushions responsible for 7.5, 8.6 and 5.4 per cent of the trunk crop, and we know that, to an extent at present unknown, the crop borne on the remainder of the tree is also affected. New cushions are however constantly formed on branches and even on twigs, and in some cases on the trunks of trees infected with canker. Having regard to the vast numbers of pods produced in excess of the nutritive capacity of the trees (*see* section on " cast-offs ") it is possible that in all except very bad cases the destruction of cushions by *P. palmivora* may not be so serious a matter as it appears.

The significance of canker as producing new foci of infection each season is however very great, and this fact alone is sufficient to justify the small effort necessary to reduce canker by the prompt removal of diseased pods.

THE CAUSE OF "CAST-OFFS."

A phenomenon familiar to all concerned with cacao cultivation is the production of very large numbers of pods which are not brought to maturity, but which die while still very small—i.e. up

to a maximum length of about three inches. This was at one time attributed to disease, but actually the small pods turn yellow and are dead or dying before *Colletotrichum*, the fungus most commonly found on them, enters the tissues. In previous work this fact led the writer to the conclusion that these pods represented crop set in excess of the nutritional resources of the trees, and subsequently cut off from the nutritional stream—a phenomenon well-known in cotton and other plants.

Recently however another theory has been suggested to the writer by colleagues who have studied cacao in Trinidad. According to the theory, a large proportion of the fruits of cacao are formed as the result of stimulation by pollination, without actual fertilisation, and development proceeds only up to a certain point, after which death ensues.

This phenomenon—parthenocarpy—is known to occur in many plants. Development may or may not be completed. It is quite possible that it may occur in cacao, but in this case it has been assumed that the arrested parthenocarpic development results in a loss of crop—i.e. that if fertilisation occurred the pods would mature and produce crop.

Whatever may be the case in Trinidad, this theory appears to be untenable in the Gold Coast. From purely empirical observation we know that (i) the process of " casting-off " occurs simultaneously throughout the farm—great numbers of small pods die off within two to three days, and the subsequent appearance on them of white spore-masses renders them so conspicuous that they are easily seen ; (ii) the number of pods cast off is so enormous that it is incredible that the trees could produce such a crop as would result from the maturation of them all.

The first of these two observations indicate that the phenomenon is due to a physiological crisis in the trees themselves rather than in the fruits, because fruits of different ages are involved. We have at present, no critical knowledge which might throw light on this fact.

In the case of the second observation, however, it has been easy to obtain illuminating confirmatory data. In each of the seven fifth-acre plots in native farms in the district covered by Anyinam Field Station, four trees were selected at random, and their cast-offs during the 1929 season were counted. From these figures, the total cast-offs for each plot were estimated, and by reference to the other production data the supposed " loss " was found.

The results are shown in Table XII.

TABLE XII.

"Cast-offs" in Anyinam Plots 1929.

(Seven plots each of 0.2 acre.)

Plot.	No. of trees.	No. of pods set.	Pods lost through disease.	Cast-offs *from 4 trees only.*	Estimated total cast-offs.	Actual Yield per acre lbs. dry.	Crop per acre represented (?) by cast-offs lbs. dry.
1	87	1,776	492	399	8,800	780	5,300
2	102	1,686	106	361	9,200	875	5,500
5	120	1,682	417	311	9,300	695	4,800
7	157	1,398	161	455	5,700	693	3,000
8	113	1,097	241	187	5,300	448	2,800
9	77	2,033	272	249	4,800	955	2,600
10	97	2,357	645	282	6,800	1,530	3,800

The estimate is of course a very rough one, but is sufficient to provide an idea of what the crop would be if it were true that cast-offs represent loss of crop. It is difficult to believe that cacao, even in the most favourable conditions, could bear such a crop. The 1929 season was a bad one, but even so these farms produced what would normally be regarded as a very fair crop.

There is a considerable variation in the ratio—number of pods matured to weight of crop produced, and it might be argued that the above estimate is an over-estimate because more but smaller pods might be set and still give an increased yield. But no such compromise is possible within the known variation of pod size.

Such evidence as we have at present, therefore, supports the view that the failure of numerous small pods to develop is due to their being in excess of the nutritional resources of the trees. Similar phenomena are well known in many orchard trees. Arrested parthenocarpy may occur in cacao, but we have yet to be shown that it materially affects the yield.

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PAPER No. XIV.

THE DETERMINATION OF INCIDENCE OF BLACK POD DISEASE OF CACAO.

By H. A. DADE.

Preliminary work on this subject, done at Anyinam, was described in a previous publication.* A further study, in more detail and with better equipment, has produced more exact data and a clearer conception of the situation.

The original work indicated that atmospheric humidity was the key factor of environment, inasmuch as infection by *Phytophthora palmivora* Butl., the causative fungus, takes place during periods in which the pod is invested with a film of moisture.

In the Gold Coast a very high degree of atmospheric humidity is sustained in farms during the major part of the cropping season—so high, indeed, that it is almost continuously critical for the incidence of pod disease, and is also above the current physiological requirements of the trees. This is due to the existence of heavy overhead and lateral protection, which is absolutely necessary in most cases in order to guard the trees from the severe desiccation produced by the *harmattan* wind during the dry season, which lasts approximately for three months, December to February. We are thus unable to eliminate the humidity factor, and in most cases it is impossible to reduce it appreciably without endangering the trees.

Although, in the preliminary work, only wet and dry bulb thermometers were available, evidence of a distinct correlation between the degrees of humidity and incidence of disease was found. But it was possible to obtain, by two readings a day, only a rough idea of day and night humidity, and no clear idea of the fluctuation of saturation throughout the twenty-four hours.

Other factors found to be operating in the farms were—contact with diseased pods, the dripping of rain or dew from diseased pods, morphological characters which favour the retention of drops of water in contact with the pods, and pre-existing canker in cushions. The last has been found to fluctuate, but within limits, and we may regard all factors as being constants for all practical purposes.

*Economic significance of Cacao Pod Diseases and Factors determining their Incidence and Control. Bull. No. 6. Gold Coast Department of Agriculture, 1927.

One other factor was considered—the existence of foci in infection, formed by diseased pods on the trees and husk-heaps. The latter are very temporary foci and do not appear to be of great importance as regards current incidence, but the diseased pods actually on the trees were recognised as very active foci, though owing to the experimental method this could not be well demonstrated.

In this subsequent work therefore the factors of humidity and active foci have been investigated more closely.

METHODS OF OBSERVATION.

No effective method of observing "branch" crop has been found, owing to the difficulty of marking and examining great numbers of pods in dense foliage at a considerable height from the ground. The use of ladders is impossible without much damage to the trees and without introducing artificial factors. It has therefore been necessary, though reluctantly so, to confine observations to the trunk crop up to about seven feet from the ground. The results obtained, therefore, refer only to this part of the crop, but it is possible to draw from them certain inferences regarding the remainder of the crop.

Every trunk-borne pod is marked by a small zinc label attached to the bark with a copper tack. Observations are made twice a week, at alternate intervals of four and three days, and an individual record of the life-history of each pod is thus obtained. Records are begun when pods reach a length of 3½ inches, corresponding roughly to the age of the pod after which there is no possibility of its being "cast-off" (*see* Paper No. XIII of this Year-Book). Cases of pod disease very rarely occur before this stage of development is reached. Data regarding incidence and foci are extracted from these records.

The foci which exist in the upper parts of the trees also affect the results, and are not recorded. This fact does not vitiate the results so much as might be supposed. The trunk crop comes on and ripens earlier than that on the rest of the tree, so that during the period of observation, which ends with the first reaping and the removal of most of the trunk crop, there are very few diseased pods elsewhere. The major part of all the crop subject to disease is under observation, and this fraction greatly exceeds what might be estimated as a fair sample.

Relative humidity or dew-point determinations made once or twice a day provide data of no critical value, nor give any conception of what occurs throughout the twenty-four hours. It is therefore necessary to obtain continuous records, and in the present work the data regarding atmospheric humidity were got by means of Edney self-recording hair hygrometers, which give a continuous record in terms of saturation per cent on weekly charts. These are placed in the middle of the farms at about four feet from

the ground under open-sided shelters to protect them from rain and falling debris. Owing to the natural shade, direct sun rays do not reach the shelters, and there is no need for special insulated roofs. A sheet of corrugated iron, bent into the form of a gable roof, is therefore sufficient. This roof is supported by four uprights of 3″ x 4″ scantling. The instrument is supported on two narrow battens, which allow free circulation of air round the hair element.

There is no perfect form of self-recording hygrometer. The Edney hygrometer has its peculiar disadvantages, which however have fortunately, in the present case, been overcome or are negligible. The ink supplied contains some hygroscopic substance to prevent its drying on the pen, and in the extremely high humidity of the farms this and the dampness of the chart causes the trace to blot and spread. Some improvement is obtained by diluting the ink, but although, as yet, no satisfactory fluid has been found, the original trace can usually be seen sufficiently well for accurate reading. Another difficulty has been protection from insects which damage the hairs, without preventing free circulation of air. No solution of this difficulty has been found, and it has been necessary to renew the hair occasionally and to keep spare instruments ready for emergencies.

The great disadvantage of this instrument is the necessity for very frequent adjustment. The usual methods—wetting the hair with distilled water, or wrapping the instrument in a wet towel,—of setting the 100 per cent reading have proved most unreliable, and owing to the lag in recording, wet and dry bulb thermometer checks have also failed to be of use. In the farms, however, we have, all through the wet season, an infallible natural check—the period of saturation which occurs practically every night. During this period the trace is a steady horizontal line, which gives a daily check on adjustment, and from which corrections to the other parts of the trace can be made.

Plate IV contains three examples of weekly charts, two of which show the nightly period of saturation. They also illustrate the conditions of atmospheric humidity in cacao farms in the dry and wet seasons.

Self-recording wet and dry bulb instruments have also been tried, but these are not so useful as the hair hygrometers. They also require frequent adjustment, and the scale of the charts is too small to show even considerable fluctuations of humidity, which—another disadvantage—has to be calculated from tables.

In this particular work, where the natural check has been available, there is every reason to believe that accurate records have been obtained with the Edney hygrometer. For this type of investigation, however, an ideal instrument is not at present known. A really accurate and easily managed self-recording instrument is needed, and in addition, one with a small sensitive element which will function at a distance from the recording machinery, so that

it can be introduced into small laboratory chambers or into close proximity with the surface of fruits, etc., in field observations, and so provide records of "micro-climate" more accurately than is at present possible.

The positions chosen for the hygrometers are such that the record gives a very fair idea of the humidity of the air in the region of the trunks of the cacao trees, and of that part of the crop which is under observation.

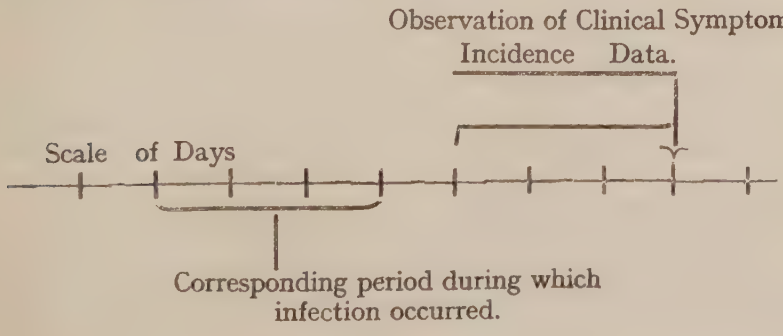
INTERPRETATION OF DATA.

Incidence of Disease.

This is calculated at each observation as a percentage of the total number of pods which were healthy on the occasion of the previous observation. The two periods in each week which elapse between observations are, however, unequal, one being of four and the other of three days. The time factor is of course of first importance in this record, because, other conditions being constant, the time which elapses is directly proportional to the number of infections. The other data with which this is to be compared can also be extracted for similar periods, but when the comparison is made graphically the curves show regular fluctuations which are due to the time factor and obscure those which are the result of those other factors which we wish to examine. The time factor must therefore be eliminated, and this is done by reducing all data to terms of three-day periods.

Incubation period.

A certain time elapses between infection and the clinical symptoms on which the recording of incidence is based. This time is variable, and for the purposes of this investigation an arbitrary average incubation period must be adopted. Four days has been adopted as the average incubation period, based on numerous field observations. In comparing incidence with its determining factors, then, allowance must be made for the incubation period, and this is done by extracting the data concerning these factors for periods four days ahead of the incidence records. This is explained diagrammatically below—



HUMIDITY AND FOCI DATA.

Foci of Infection.

This factor is recorded as the percentage of the pod population which is actively infectious. A pod is infectious—that is, infection can be carried from it by various agencies—for about 10 days, after which it is so overgrown by saprophytes that few viable *Phytophthora* conidia remain and it is of no significance as a focus. In this work it is assumed, therefore, that a pod is infectious for three half-weekly periods, and it is then excluded from the total population on which the value of the foci factor is calculated. The adjustment for incubation period is then applied.

Humidity.

This is recorded as the number of hours during which relative humidity was sustained above 98 per cent saturation. Actually condensation does not occur until relative humidity rises to 100 per cent saturation, but the lower limit of 98 per cent is selected because there is a slight lag in the recording instrument, and moisture is deposited on the pods before the hygrometer registers 100 per cent; and moreover the film persists for a time after humidity has fallen below 100 per cent saturation. Trials have been made using still lower limits, but these do not show such close correlation, so 98 per cent has been adopted as being probably the best standard in what is, after all, not an exceedingly accurate record. No record of relative humidity, with the instruments at our disposal, can be, for even with a good psychrometer, readings can only be got, in the higher ranges, to within one or two per cent saturation.

Reduction to three-day periods and adjustment for incubation period have been applied to this record.

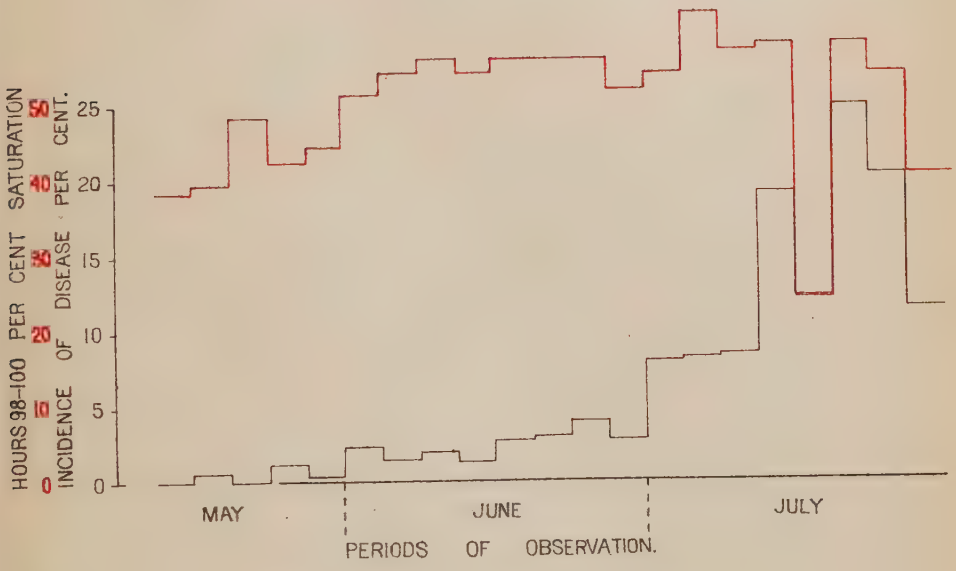
The data described here were recorded on Plot I, Anyinam from 6th May to 25th July, 1929, after which the crop was reaped.

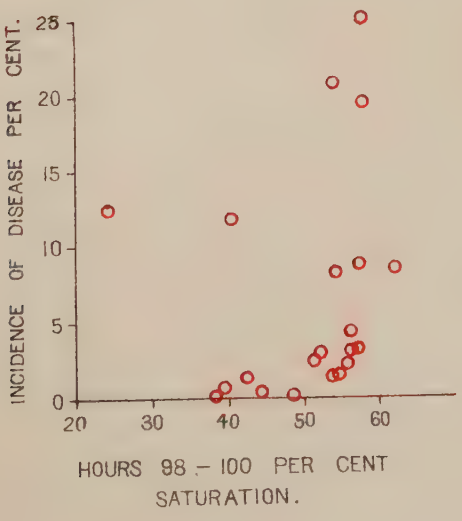
RESULTS.

These are shown graphically in Plates I–III. Plate I shows incidence of disease compared with humidity alone. Correlation is apparent only in the more marked fluctuations in the histograms, and in the correlation diagram it is not perceptible. This is partly so because during the experiment there was no period when saturation did not occur—there were always conditions of humidity which rendered infection possible. In the driest three-day period there were twenty-four hours of saturation. For a large part of the experiment, humidity was fairly steady between 50 and 60 hours saturation per period.

Plate II shows incidence compared with the foci factor—the percentage of the pod population which is infectious. Here, in the histograms, we see a distinct tendency to a progressive rise

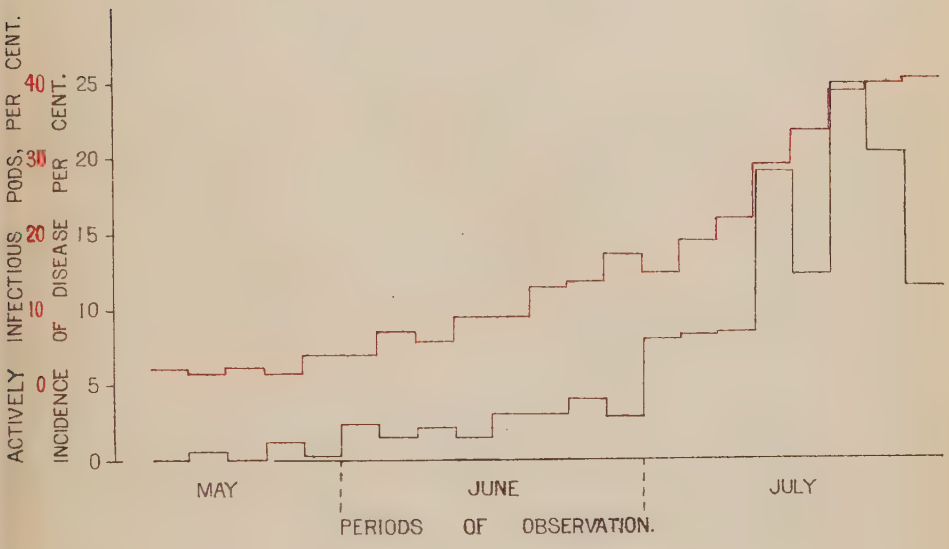
INCIDENCE OF POD DISEASE AND ATMOSPHERIC HUMIDITY.

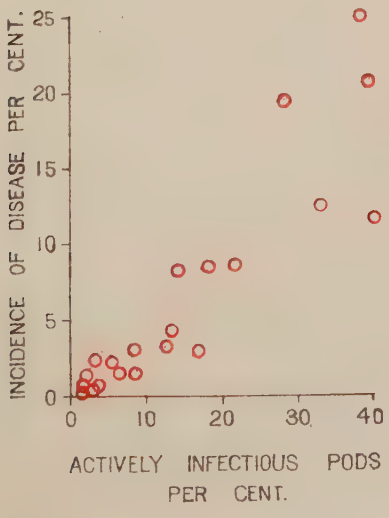




SURVEY H.Q. ACCRA, 1931.

INCIDENCE OF POD DISEASE AND FOCI OF INFECTION.





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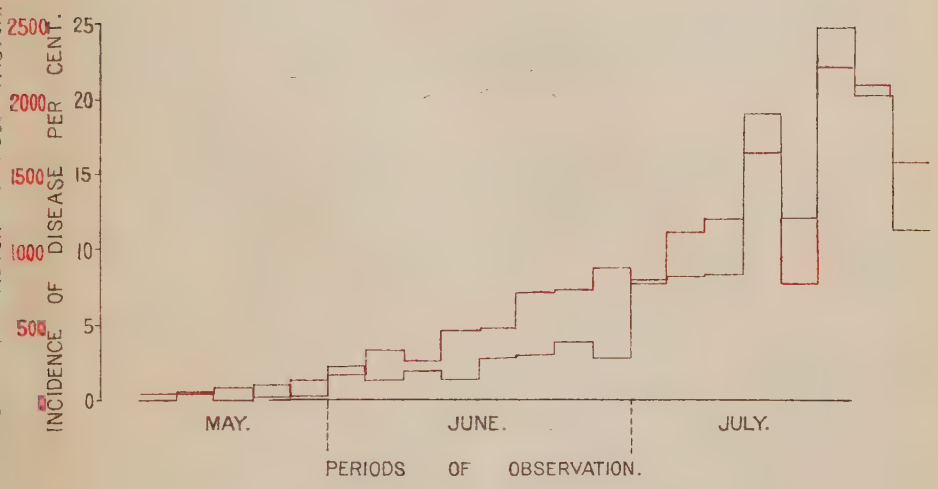
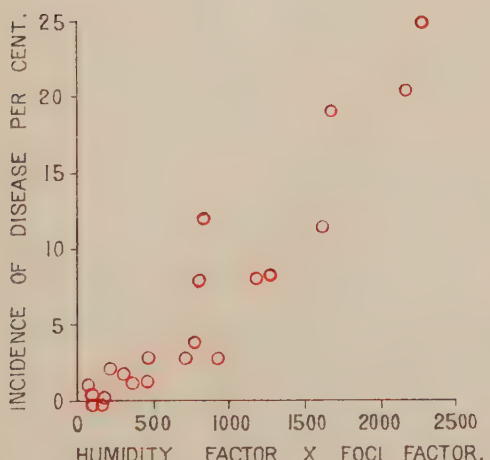




toward the end of the experiment, but in detail correlation is not good, nor is it good in the correlation diagram.

Plate III shows incidence compared with the product of the humidity and foci factors. In this case good correlation is found, both in the histograms and the diagram, and we may conclude that the factors which we have been considering are those which mainly determine fluctuations in incidence. Having regard to the numerous, though in the circumstances unavoidable, imperfections of method, the discrepancies are not great.

In the earlier part of the experiment, however, reference to all the histograms shows a certain negative correlation in the fluctuations, though the general tendency to progressive rise is positive. It may be that this discrepancy in detail is due to the incubation period varying, with resistance, during the season

The results indicate—

(i) that the incidence of pod disease, with its direct economic effect of loss of crop, is determined by the length of time during which the atmosphere is saturated with water (and consequently the pods are invested with a film of moisture) and by the proportion of actively infectious diseased pods in the farm ;

(ii) that the other factors, which have been mentioned as constants, are subsidiary ones, because they are active only as the result of one or both of the main factors specified in (i), with the exception of canker. Infections due to canker are dependent neither upon external humidity nor upon external sources of infection. They are however a legacy from the external conditions of the previous season, and are ultimately subject to the same control as other infections ;

(iii) the confirmation of methods of control recommended in the past. We cannot to any extent control the humidity factor, but we can control both spread of infection and canker by prompt removal of pods in the early stages of disease.

Reference has been made to inferences which may be drawn regarding that part of the crop which was not under observation—that of the upper trunk and branches, which bear, in the average Gold Coast type of tree, from four to ten times the number of pods found on the lowest seven feet of the trunk. In the topmost branches ventilation is free, and the periods during which condensed moisture is retained on the pods is no doubt much shorter. In the main part of the branch system, however, the advantage of proximity to the free air above the farm is probably neutralised by the much greater obstruction of circulation by the foliage.

The principles governing incidence of disease in the upper part of the tree are no doubt the same as those which apply to the lower

trunk crop, the difference being only one of degree. Some of the constant factors, more particularly those associated with contact, and probably that of canker, are of less significance, but this does not affect the importance of the two main factors.

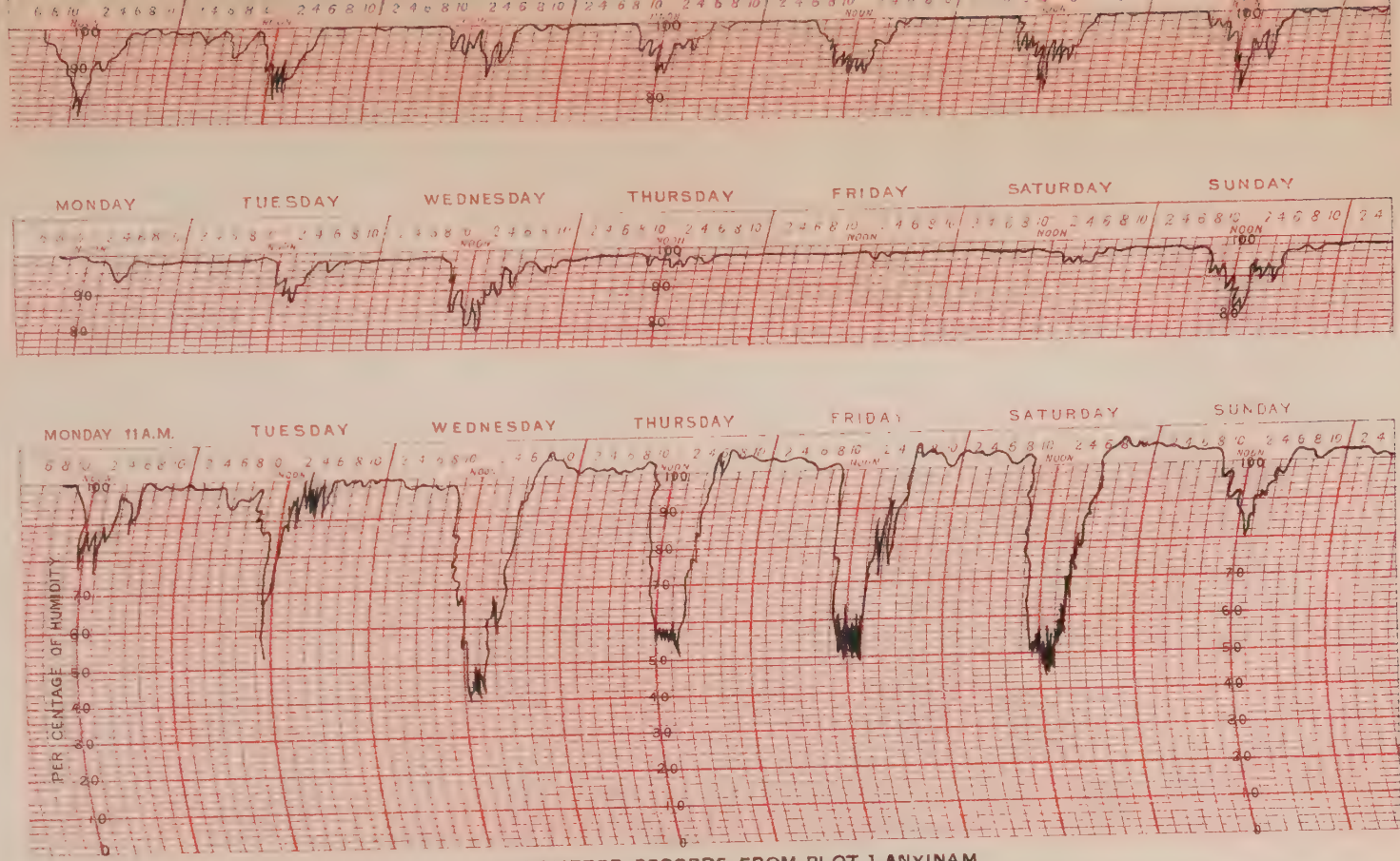
It is of interest to compare the conditions determining the incidence of infection by species of *Phytophthora* in this and in temperate climates. In the case of potato blight (caused by *P. infestans*), for example, both sustained saturation (with other conditions, cloudiness, and rainfall favouring precipitation and retention of the film of moisture) and favourable temperature (not below 10° C) are necessary for an outbreak of disease to occur. This is the basis of Van Everdingen's formula, by means of which the Dutch forecast outbreaks of potato blight and thus are enabled to apply control measures effectively.

In the tropical rain forest, however, the situation is much simpler. Temperature throughout the year is not a limiting factor, and is indeed consistently close to the optimum temperature for the growth of *P. palmivora*. For eight or nine months of the year, too, conditions of humidity are practically continuously favourable for infection.

Thus, in the Gold Coast cacao areas, isolated outbreaks do not occur—the disease is continuously active though its activity fluctuates with the determining factors. These conditions profoundly affect methods of control, and it is obvious that ordinary spraying schedules similar to those in use in temperate climates cannot be applied. To be quite effective, spraying must be so frequent that it becomes economically impracticable, and the difficulty is accentuated by the frequent heavy rain which often removes the fungicide before it has had time to adhere to the pods.

In the case of the Gold Coast, a further difficulty is provided by the primitive stage of development of agriculture, which is in the hands of an illiterate, conservative and improvident peasantry.

We are thus forced to the conclusion that in these conditions we have in sound cultivation and sanitation a more satisfactory protection against pod disease than in artificial means of control.



HYGROMETER RECORDS FROM PLOT 1, ANYINAM.

The topmost is a typical wet season record, and the instrument is in correct adjustment. The second is a record showing a period of high sustained humidity — a "wet spell" — such as results in high incidence of disease; the instrument is out of adjustment by 2 per cent. These two charts show the straight line traces representing 100 per cent saturation, which can be used for correcting the record. The lowest chart is a typical dry season record for comparison with the others. The instrument is thrown out of adjustment by the sudden change of conditions, and in the absence of the straight line 100 per cent traces cannot be accurately corrected.

PAPER No. XV.

VEGETATIVE REPRODUCTION IN CACAO.

By G. H. EADY.

Temperate fruits—apples, pears, cherries, plums, peaches, grapes, walnuts, etc.,—have been propagated asexually for hundreds of years with very marked improvements in uniformity, quality and quantity.

In the tropics, until comparatively recently, all fruit trees were raised from seeds, but with the advent of more rapid means of transport, and increased demands for tropical fruits, growers soon realised that uniformity of their produce was essential and that this desirable characteristic could not be obtained from seedling trees.

Citrus in particular, although stated by some authorities to come true to seed, was one of the first fruits to be budded or grafted, and this method of propagation is now general, except in countries where citrus culture is neglected.

Mangoes, Avocado pears, Coffee, Hevea and many other tropical and semi-tropical fruits and economic trees are now propagated asexually, resulting in marked improvements in bearing capacity and uniformity as compared with seedlings.

It is safe to assume that if such improvements in temperate, sub-tropical and tropical fruits can be obtained by asexual methods of propagation, bearing capacity, uniformity of beans and quality in cacao could be improved to a considerable extent and by similar methods.

Cacao is always raised from seed by the peasant farmer in the Gold Coast, the pods usually being indiscriminately used without consideration as to whether the parent tree is or is not a prolific bearer, or produces beans of good quality.

Individual records of a large number of cacao trees collected over a period of nearly 20 years disclose that, whereas some trees are consistently high yielders, others do not produce more than two or three pounds of cacao in any one season and many much less than this. Since every farm or plantation in the Colony is composed of trees of these mixed types the potentialities for very considerable improvements in yields and quality are obvious.

No definite proof that cacao plants raised from seeds selected from consistently high-yielding trees will transmit their high-yielding characteristics to their progeny are yet available in this

country. They may or may not do so there being no known method, excepting by trial, to determine these points.

It may be reasonably expected that a proportion of the seedlings will inherit the desirable high-yielding characteristics of their parents and once this has been proved in the second generation it is probable that the third and subsequent generations will retain these characteristics.

A plot of Amelonado cacao consisting of seedlings raised from seed of the highest-yielding cacao trees at Aburi was planted out on the Kumasi Experiment Station several years ago, but has not yet reached the stage at which yields can be correlated with the high yields of the parent tree.

Cacao trees propagated by vegetative methods do not exist anywhere in the Gold Coast, therefore comparison between yields of seedlings and asexually produced plants cannot be made at the present time.

Extensive experiments in the latter method of reproduction have however been carried out by the Division of Horticulture, during the past two and a half years. The results of these tests prove that budding is practicable though difficult, and that 80 per cent of successes can be obtained by this method.

Many methods of vegetative reproduction have been tested with the following results :—

Cuttings.

These have been taken from every part of the tree including water shoots, large branches and even the main stem. Large numbers of specially prepared cuttings were stratified in damp sand to induce callus formation, and many types of rooting medium were used, from pure sand to pure clay and in situations varying from being in dense shade to being in full sun.

In no instance could any sign of callus or root formation be detected, most of the cuttings being dead within a week. This method has proved entirely unsuccessful.

Layering.

Hundreds of branches of trees in Cacao plot 11 were layered by the usual method of making a diagonal cut half-way through a node, by ring barking, and by fracturing the stem, the branches being layered either in boxes of soil, large flower pots, tubs, or in the soil of the plantation. The chief difficulty experienced was preventing movement of the pegged-down branches, and it is probably due to this factor that results were unsatisfactory.

A few plants have been produced by this method, which although possible, is slow and not considered practicable.

In-arching.

In this method it is necessary to raise stocks in bamboo pots, fix the pots to strong stakes, and place the stakes near a suitable

branch. The difficulty experienced was that by the time the stocks were large enough the bamboo pots were decayed or destroyed by white ants. Cacao seedlings do not thrive well in pots, but even so it is possible to produce plants in this manner.

The junction has of necessity to be high up on the stock, and is undesirable in cacao which frequently fruits at ground level on the main stem.

Gootee Layering.

A small percentage of successes have resulted from this method which is effected by wounding or ringbarking a portion of a branch about 12 inches from the apex, surrounding the wounded portion with a ball of soil, covering with moss, and binding it to the branch. For upright branches, split bamboo pots may be used, the two halves being fitted to the branch separately, bound together and then filled with soil. The soil must be maintained in a moist condition either by the use of a watering-can or by a vessel of water suspended above the layer, the water being conducted to the soil by a wick of suitable material.

Roots are produced in a few months, when the branch may be severed. When a large number of plants are required quickly this form of propagation is not recommended. It is practicable if only a few plants are required for experimental purposes.

Root Wiring.

Many plants will produce aerial growth from totally exposed roots if a piece of strong wire is twisted around a lateral root close to the collar. Sections of the lateral root with the new growth may thus be treated as separate plants. This method has not proved successful at Aburi, most of the lateral roots dying soon after exposure and wiring. Two plants were however obtained, but died soon after they were planted out.

Grafting.

Many methods of grafting have been tried with stocks and scions of different sizes and ages. The scions all died within one week without union being effected.

Budding.

In October, 1928, 9,000 stocks planted were raised from seeds selected from 300 trees, each line of 30 plants being given the number of the parent tree. A number of seedlings were raised in bamboo pots at the same time.

Up to the middle of September, 1930, i.e. two years later, over 3,000 of these stocks have been budded, the buds being selected from some of the highest yielding pedigreed trees at Aburi.

Many methods of budding were tried on stocks varying from six months to two years of age. Buds were taken from different portions of twigs, water shoots, branches and stems. The tying materials were raffia, tape, grafting tape, insulating tape, Silko

and wool, used either as bought, or impregnated with paraffin wax. Of the 3,000 stocks budded, only ten proved successful, the " buds " generally decomposing within a week after insertion.

In September, 1930, a system of " H " Budding was devised with very considerably improved results.

" H " Method of Budding.

An elongated H shaped cut is made on the stem of the stock as near ground level as possible. The length of the longitudinal side cuts should be from 3½ inches to 4 inches with a horizontal cut joining the two side cuts in the centre. The distance between the side cuts naturally varies with the size of the stocks, but it should not be more than half the diameter

Budding should only be attempted when the stocks are in an active condition of growth which is denoted by the new foliage produced. This condition occurs several times during a year, one of the periods being in the middle of the dry season.

Preparation of the Buds.

Experience has proved that buds must be selected from wood three to five years old, and that those taken from younger wood are unsatisfactory. The buds must be forced into slight growth by heading back the branches several weeks before budding operations take place.

Buds must be from 3½ inches to 4 inches in length and of a width suitable to the stocks. A perfectly clean sterilised sharp knife should always be used, and the bud itself must not be damaged. The woody portion at the back of the bud must be carefully removed, before the bud is inserted into the stock.

Insertion of the bud into the stock.

The bark of the stocks previously prepared should be carefully lifted and the two sections held apart whilst the bud is inserted, and immediately covered again. This operation together with the removal of the bud from the selected branch must be carried out quickly, otherwise the delicate cambium layer will be damaged. The bud may be tied in with any suitable material, narrow tape being useful for the purpose. Hot paraffin wax should then be painted over the wounded area with a soft brush.

As soon as the bud begins to grow the stock should be cut back as close to the bud as possible, and no subsequent growth from the stock allowed.

Six months after the bud has taken, the plants may be planted out in their permanent quarters. All growth occurring on the stock must be rubbed out when quite small by pruning and tarring the young tree.

SUMMARY.

1. Figures comparing yields between budded and seedling cacao will not be available in the Gold Coast until the plots of budded plants at Kpeve Investigational Station come into bearing

2. Comparison of yields between the high-yielding Amelonado cacao trees at Aburi and the seedling progeny raised from these trees and planted out on the Kumasi Experimental Station cannot be made until these seedlings are several years older.

3. Cacao raised from seed may or may not inherit the high yielding characteristics of the parent tree.

4. Budded cacao may inherit the high-yielding characteristics of the scion mother or totally fail to do so. Trials alone will determine this point.

5. No information is yet available as to the influence a particular stock may have on the scion, but if the desired characteristics are transmitted by a certain combination of stock and scion to the second generation, the probabilities are that this character will be fixed.

6. Cacao cannot be propagated by cuttings by any method yet tried.

7. The grafting of cacao at Aburi has proved impossible with every method experimented with to date.

8. Cacao can be reproduced by several methods of layering, but entails a large amount of work and careful supervision. Roots are formed very slowly. Despite these difficulties comparisons between layered and budded plants would yield interesting information, since layered plants should, other factors remaining the same, be a replica of their parent.

9. In-arching is possible but since portions of separate plants are used no advantage over budded plants would result, budding is undoubtedly the easier and better method.

10. Budding is considered to be the best method of propagating cacao vegetatively, and in quantity, the disadvantage being that the influence of the stock on the scion is an unknown quantity.

11. Budding should only be performed when marked flushes of growth occur ; buds must be forced into slight growth by heading back the branches.

12. The best results have been obtained with buds $3\frac{1}{2}$ inches to 4 inches in length and subsequently painting over completely the budded area with hot paraffin wax.

13. The information given in connection with experiments outlined in this paper on vegetative reproduction in cacao are the results of tests initiated by the writer in the Botanic Gardens, Aburi.

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PAPER No. XVI.

COLA SURVEY: EASTERN ASHANTI AREA, AND A GENERAL REVIEW OF THE COLA INDUSTRY.

By A. C. MILES.

INTRODUCTION.

During the months of January–June, 1930, a survey of the Cola areas in the Eastern Province of Ashanti was carried out by Mr. J. C. Muir and Mr. J. D. Broatch, Assistant Superintendents. The former officer was responsible for the survey of Western Ashanti, which formed the subject matter of Paper No. XXVII in the 1929 Year-Book.

In order to check the data obtained in the field, and to ascertain the actual state of the industry, it was found necessary to record the movement and tonnage of Cola leaving Ashanti. Enquiry and observation served to show that the main flow of traffic is to the north, and, apart from despatches by rail, the quantity leaving Ashanti by routes other than those crossing the River Volta is negligible. Arrangements were made to check the quantities of Cola crossing the ferries at Bamboi, Morna, and Yeji, during the crop year 1929–30. These recording posts will be maintained for an indefinite period.

COLA AS A MEANS OF BARTER.

Cola is indigenous to Ashanti and was used as a means of barter long before Europeans knew the country. The Ashantis have always been alive to the value of the crop, and although of late years cacao has become popular, the Cola industry has been maintained in a reasonably stable state, and there are no indications of its sharing the fate of the Palm Oil industry of the Colony.

MARITIME EXPORTS TO NIGERIA.

For many years the Gold Coast has been exporting large quantities of fresh Cola nuts to Nigeria, and as transport systems developed in both countries, the trade in nuts increased until 1924 when it reached the maximum of 7,800 tons. Until 1916 Nigeria was entirely dependent on Gold Coast supplies, but in 1917 Sierra Leone started sending nuts to Nigeria, and, in spite of the greater

distance and higher freight charges, has continued to develop the export industry. Starting with 4 tons in 1917 which represented 0.13 per cent of the Gold Coast exports for that year, Sierra Leone has expanded her trade to such an extent, and in spite of an export tax, that in 1924 it amounted to 845 tons or 11 per cent of the total exported from the Gold Coast. Since 1925 our maritime exports of Cola have fallen off seriously and in 1929 the total was only 3,044 tons. Sierra Leone, however, continues to compete for the Nigerian trade and in 1929 landed 1,651 tons in that country, or 61 per cent of the Cola imports from the Gold Coast.

COMPARISON OF OVERLAND WITH MARITIME EXPORTS.

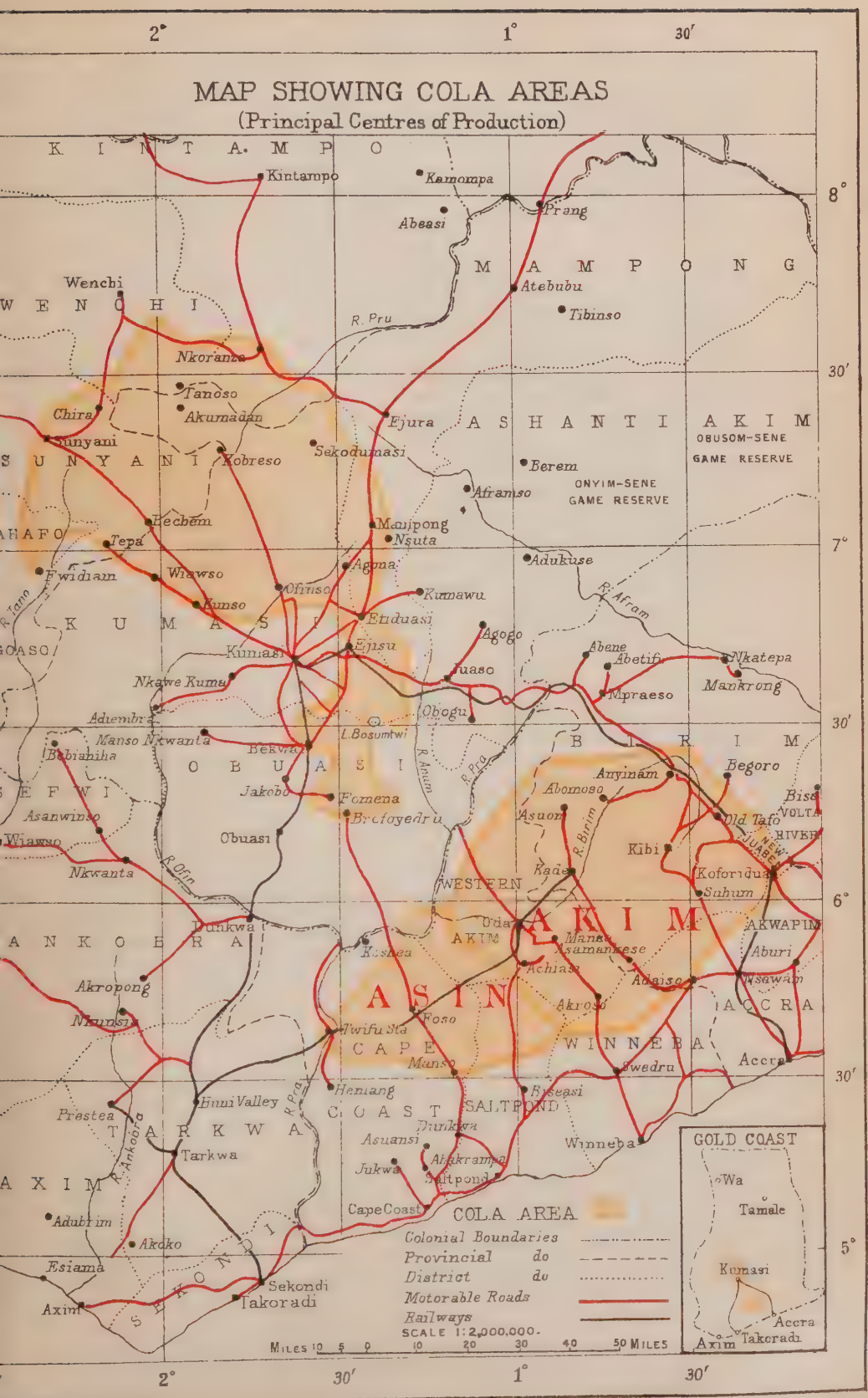
The diminution of maritime exports has attracted attention and given some cause for alarm, meantime, however, observations led the Department to suppose that overland traffic to the north was increasing, and it seemed likely that the decrease in the former was coinciding with this. Improved transport facilities and the development of motor roads, with the consequent increase in motor traffic, all tended to support the latter theory, but in the absence of proof, a survey of the industry became necessary. This was commenced in 1928 by defining roughly the natural distribution of the crop, followed later by a local survey of the producing areas of Western Ashanti, and more or less completed during 1930 by similar methods throughout the producing areas of Eastern Ashanti. During the interim, the output from producing areas has been checked at Bamboi, Morna, and Yeji. In addition, movement by rail has been recorded, and maritime exports carefully watched.

PRODUCTION IN THE COLONY.

In this connection useful evidence has been obtained, which serves to show that production within the Colony is appreciably greater than anticipated, and that a high percentage of the maritime exports are derived from the Akim and Assin countries. Crop surveys of these areas have not been undertaken but their total production can now be estimated with a reasonable degree of accuracy, and will be referred to later.

PRODUCTION IN ASHANTI.

Production within Ashanti has now been ascertained, and, with the aid of records of crop movement throughout the year, the output from districts can be defined fairly accurately. In the report on Western Ashanti, 1929 Year-Book, Paper No. XXVII, the methods used to obtain information are explained, while the questions of rainfall, soils, and production as compared with actual sales, or output, were fully described, and in general, apply equally well to the producing areas of Eastern Ashanti, reported herein. The two districts mainly responsible for production in Eastern Ashanti



SURVEY H.Q. ACCRA, 1981.

are the forest areas of Kumasi and Mampong. The approximate production in tons from each district being as follows: Kumasi 1,600, Mampong 1,300, Ashanti-Akyem 200; Obuasi 50, Bekwai 30. This total of 3,180 may be expected to show variations from year to year, and may be as low as 3,000, or as high as 3,500 tons.

THE COLA CROP YEAR.

In the past, statistics relating to Cola have been compiled for calendar years. Reference to records of crop yields at the Department stations—Aburi and Kumasi—serve to show that the crop production year extends from September to August, whereas statistics relating to movement of the crop can be best correlated with production for the period October to September. In a later paragraph, statistics for the calendar year and export year are compared and serve to show how misleading the former may be. During the months November to March inclusive, the greater part of the crop is exported; thus the practice of recording for a calendar year is misleading as parts of two crop years are included. For the purpose of compiling statistics showing seasonal production of Cola, the twelve months from 1st October to the 30th September, should be used. The lag, or period which elapses between harvesting and export, appears to be approximately nine weeks, most of which time is taken up in curing the nuts.

EXPORT STATISTICS FOR CALENDAR AND CROP YEARS.

Maritime exports of Cola show marked periodic increases from 1903 until 1919, then a period of fluctuation during which time the industry was adjusting itself to meet the newly imposed Nigerian duty and increased tariff in French West Africa. Recovery was not complete in 1921 when an export tax was imposed. This seemed likely to prove fatal but fortunately it was repealed the following year. Figures for 1923 show a marked increase, and the improvement continued throughout 1924 when the maximum was reached. The following year there was a decrease of approximately 20 per cent and annual decreases have continued as may be seen in the following table, compiled from Customs records:—

TABLE I.

TONNAGE EXPORTED FOR CALENDAR YEARS 1924 TO 1930.

Ports.	1924.	1925.	1926.	1927.	1928.	1929.	1930.
Accra ..	3,109	2,438	2,059	1,949	2,661	1,948	1,768
Central Province Ports	2,876	1,402	2,172	1,692	1,528	913	1,251
Takoradi ..	1,788	2,256	1,337	1,487	739	183	717
Totals ..	7,773	6,096	5,568	5,128	4,928	3,044	3,736

TABLE II.

TONNAGE EXPORTED FOR CROP YEARS 1923–24 TO 1929–30.

Ports.	1923–4	1924–5	1925–6	1926–7	1927–8	1928–9	1929–30
Accra ..	2,808	2,506	2,194	1,796	2,645	2,262	1,744
Central Province Ports	2,798	1,670	2,133	1,791	1,577	1,206	1,064
Takoradi ..	2,051	2,249	1,768	1,393	865	302	721
Totals ..	7,657	6,425	6,095	4,980	5,087	3 770	3,529

A comparison of the figures in the above two tables will serve to prove the statement concerning them which is made above. It will be seen that by the method of recording used in Table II there was a slight increase in the 1927–28 exports, while the apparent increase of 692 tons shown in the former table for 1930 is actually due to the greater output of 1928–29, and the total for 1929–30 was in reality 241 tons below the previous crop year.

PRODUCTION AREAS.

In Tables I and II exports are shewn for the provinces and it is at once apparent that the falling off in exports is most marked from the Central Province ports and Takoradi. Tonnage shipped from Takoradi was derived exclusively from Ashanti until 1929, when small quantities came from other sources as the Central Province railway construction reached the Cola areas. Exports from the Central and Eastern Provinces are derived principally from Assin and Akim, and the bulk of these parcels are motor borne. Decreased exports from these ports is thought to be due to ever-increasing production of cacao and the larger profits to be derived therefrom. In the case of reduced railings from Ashanti, however, it is evidently due to larger quantities being despatched by the northern overland route.

THE OVERLAND EXPORTS OF COLA.

The numbers of loads of Cola recorded for the years 1924 to 1929, have been converted to the same unit as that employed for calculating tonnage checked in 1930, and, while absolute accuracy is not claimed for the figures obtained, the method does at least render the data more readily comparable. Table III serves to show the total exports from Ashanti, and tonnage railed from Kumasi is shown in a separate column to facilitate comparison with maritime exports from Takoradi.

TABLE III.

TOTAL COLA EXPORTS FROM ASHANTI IN TONS—CALENDAR YEARS 1924 TO 1930.

Year.	South by Rail from Kumasi.	North by Motor and other means (approx.).	Total.
1924	2,449	2,086	4,535
1925	2,947	2,929	5,876
1926	2,050	3,487	5,537
1927	2,006	3,387	5,393
1928	759	3,206	3,965
1929	348	3,937	4,285
1930	753	4,650	5,403

It is unfortunate that the past records are for calendar years and cannot be transposed to crop years, as it seem likely that the traffic would show a steady increase except for 1928, and in that case it might indicate that the crop was small for that season.

ASHANTI PRODUCTION FIGURES.

The data given in Table III above are of special interest as they serve to show for the first time the actual tonnage of Cola exported from Ashanti. Figures for 1930 show an increase of 1,118 tons over the previous year, but much of this may very probably be due to greater care in recording. A better measure of the increase may be obtained by comparing the exports for 1924 with those of 1930, as follows :—

Year.	Railings.	Overland.	Total.
1924	2,449 Tons	2,086 Tons	4,535 Tons.
1930	753 Tons	4,650 Tons	5,403 Tons.
Increase or Decrease	—1,696 Tons	+2,564 Tons	+ 868 Tons.

This serves to show that exports from Ashanti have increased substantially during the period and that the direction of traffic has definitely changed in favour of the northern overland route.

ECONOMIC REASONS FOR THE CHANGE IN DIRECTION OF TRAFFIC.

There are several reasons for this change of direction and they are all due in some measure to the economics of the industry. Men from the north come south to the Cacao areas for the major crop

harvest, and when returning invest part of their earnings in Cola. These, like the petty dealers in the commodity, carry their own load and can readily dispose of nuts on the way, thereby avoiding waste through deterioration, while realising sufficient to maintain themselves during the journey. The merchant dealing in tons of Cola, borne by motor-lorry, is equally well favoured and can realise his investment in a very short time, without undue risk of deterioration. Having purchased the nuts he can load them at his convenience, and even if cash must be paid in advance for transport, there are good markets such as Tamale and Wa within easy reach, and still better prices to be obtained at places like Bawku near the frontier. All these northern markets are sufficiently near to enable the merchant to turn over his cash within a few days, involving little risk and a minimum outlay of capital during the interim.

THE MAIN TRADE ROUTES TO THE NORTH.

Reference to the records of quantities crossing the ferries northwards will show that Yeji, on the old Kumasi-Salaga-Tamale-Bawku trade route, is the busiest of the three routes. It is open to motor traffic for ten months of the year, is the oldest motor road to the north, and traverses the eastern side of the Northern Territories. Traffic over Morna Ferry is about one-fourth of that crossing Yeji, but there is no motor road beyond Kintampo and all produce is conveyed by head-load or donkey transport, the former averaging 80 lbs. per load, and the latter 160 lbs. Data from Bamboi show that the tonnage is equal to about half of that passing Yeji ; it is on a motor road traversing the western side of the country and still in process of extension.

DERIVATION OF OVERLAND EXPORT TRAFFIC.

The tonnage recorded during the crop season October, 1929 to September, 1930, and the derivation of nuts, is shewn in Table IV which follows :—

TABLE IV.

DEPARTMENT OF AGRICULTURE RECORDS FOR COLA (IN TONS). GOING NORTH 1929–30.

Ferry.	Origin of Nuts.			Totals from all parts.
	Ashanti.		Colony all parts.	
	Eastern.	Western.		
Yeji	2,375	110	28	2,513
Bamboi	360	899	3	1,262
Morna	273	398	.6	671
Totals ..	3,008	1,407	31.6	4,446

The survey has produced the following interesting facts concerning production of exportable cola nuts.

During the crop season 1929–30, Ashanti disposed of 5,208 tons, of which 4,415 tons were sent north overland, and 793 tons south by rail for export by sea. These exports were derived as follows: Eastern Province 3,455 tons; Western Province 1,753 tons. During the six years ending December 1930, the total output from Ashanti shews an increase of 868 tons, and, while the ocean exports have fallen by 1,696 tons, overland traffic has increased by 2,564 tons.

REVIEW OF TOTAL EXPORTS.

The foregoing refers particularly to Ashanti output during the past seven years and may be regarded as satisfactory. When reviewing the total output from the Gold Coast, however, it becomes evident that the trade is diminishing, and the change in direction of traffic results in a considerable loss of revenue in railway earnings. During the years 1924 to 1927, the mean tonnage carried by rail from Ashanti was 2,400, whereas during the period 1928 to 1930 the mean tonnage amounted to 650 only.

In the table below, the total output from the Gold Coast for 1923–24 crop year is compared with the same period of 1929–30.

TABLE V.

Year.	Marine Exports.	Overland Exports.	Total (Tons).
1923-24 ..	7,657 Tons	*2,086 Tons	9,743
1929-30 . ..	3,529 Tons	4,446 Tons	7,975
	—4,128	+2,360 Tons	— 1,768

*Calendar Year.

This serves to show that the total decrease in output amounts to 1,768 tons, and although some of this amount may be due to comparing a crop year with a calendar year, it will be seen on reference to Tables I and II that the greatest range of variation occurs in 1929 and amounts to some 700 tons. It thus becomes evident that there is a definite decrease in total output, and the survey shews that this may be attributed to the Assin and Akim production areas. Reference to Table II will show that exports from Accra (supplied by the Eastern Akim areas) were reasonably

stable for the six crop years ending 1928–29—the mean annual tonnage being 2,386, whereas in 1929–30 exports were 624 tons below the mean, thus accounting for 35 per cent of the total decrease.

TRACING THE DECREASE IN OUTPUT.

Further reference will show the greatest diminution to be taking place at Central Province ports (supplied by Assin and Western Akim production areas) where there has been a steady decrease during the past four years. The mean annual exports from these ports for the six years ending 1928–29, amount to 1,862 tons, whereas in 1929–30 the total was only 1,064 tons, or 798 tons below the mean, equivalent to 45 per cent of the total decrease.

It is evident that the Cola industry in the Colony is being adversely affected by cacao production ; the supply of labour being limited, one industry is developed at the expense of another. Transport facilities in Assin and Akim have been improved tremendously during the past six years, and savings thus effected have benefited the cacao producers, and encouraged them to extend farm areas. Meantime the Cola output has fallen from some 6000 tons in 1923–24 to rather less than 3,000 tons in 1929–30.

COMPETITION FROM SIERRA LEONE.

In a preceding paragraph, reference is made to the Cola exports from Sierra Leone and the rapidity with which that export industry was developed. Since the latter was progressing while Gold Coast exports were diminishing, it was assumed that Sierra Leone nuts were preferred in Nigeria, and competition from that country was such as to ensure the supply equalling the demand. Comments were made on the alleged superiority of the nuts, the excellent type of package and method of packing, the necessity for improving the Gold Coast type in order to compete, etc. As the result of a general survey of the industry extending over rather more than two years it has not been possible to prove the accuracy of these allegations and while obviously plausible, they are but theories. It seems more probable that the reason for the Sierra Leone export trade increasing, was due firstly to a growing demand in Nigeria, and secondly to the inability of Nigeria to obtain sufficient nuts from the Gold Coast. The reasons for Ashanti nuts being despatched by the overland route have already been explained and reasons for lack of attention to output from the Colony are given in the preceding paragraph.

In support of the statement made above, the following tabulated costs are given for comparison, and leave no room for doubt as to preference or necessity, since it shows that Sierra Leone nuts cost nearly eight pounds per ton more than the Gold Coast product when landed in Lagos.

TABLE VI

Comparative Charges per Ton of Cola Nuts.

Items.	Sierra Leone to Lagos.	Gold Coast ports to Lagos.
	£ s. d.	£ s. d.
Export Duty	4 13 4	—
Ocean Freight	6 15 0	3 10 0
Ocean Insurance	0 6 0	0 5 0
Import Duty	14 0 0	14 0 0
Harbour Dues	0 6 0	0 6 0
Total Charges ..	26 0 4	18 1 0

To the above charges the cost of nuts at ports must be added. Information on this point was sought from the Department of Agriculture, Sierra Leone, and the Director very kindly gave full details as to sources of supply, value of nuts, distance from ports, and cost of freight to Freetown. It was thus possible to compare costs, and it is particularly interesting to record that producers in both countries get approximately the same sum per hundred nuts. Transport charges show no appreciable difference and the value of nuts at ports of shipment in both countries is £15 to £20 per ton according to size and season. It will thus be seen that when the charges shewn above are added to the wholesale value of nuts at ports, the total outlay per ton of Cola landed in Lagos is £33 to £38 from the Gold Coast, and £41 to £46 from Sierra Leone. In addition to the capital thus involved in landing nuts at Lagos, further information has been obtained which states " only an insignificant quantity is retailed there " and consequently transport charges must be incurred in forwarding the nuts to northern marketing centres. The quotation above is taken from a minute submitted by the Comptroller of Customs, Lagos, in March, 1929.

In conclusion there is yet another comparison which is of some significance. The export trade in Cola nuts from the Gold Coast is entirely in the hands of Africans, whereas that between Freetown and Lagos is controlled by Syrians. The keen business acumen of the latter has stimulated the Sierra Leone trade to such an extent that it must have proved profitable and this being the case, the question arises as to why they have not made a serious attempt to obtain control of the Cola trade of the Gold Coast. This, however, is one of the problems which were not solved in the course of the survey.

PAPER No. XVII.

RESULTS AT THE COCONUT PLANTATION, ATWABO.

By W. C. FISHLOCK.

The primary object in view in establishing a coconut plantation at Atwabo was to demonstrate clearly to the people of the area that an industry in coconuts and copra could be successfully established in the Nzima Country, which is that area of country from the mouth of the River Ankobra to the River Tano, and the strip of sandy country lying between the Juen Lagoon and the sea, from Half Assini to Newtown.

The plantation having been successfully established and brought to the bearing stage, it followed naturally that investigations into various matters affecting the cultivation of coconuts and the making of copra should be started there. These investigations were commenced late in 1927, when a European officer was first permanently stationed at the plantation.

The purport of the present paper is to set on record the results so far obtained from some of these investigations. Such information will undoubtedly be of considerable value in connection with the development of the new industry.

Planting began in April, 1921. A few palms flowered during 1925, and dry nuts were first collected early in 1926. The making of copra was started in a small way early in 1927. Late in 1927, a dryer, for making copra by the aid of artificial heat, was erected. This dryer is described in Paper No. XVII of the 1927 Year-Book, pp. 110–111. From that time onwards copra has been steadily produced. The amounts produced annually are shown in Table I. (The financial year, 1st April to 31st March inclusive, is taken.)

TABLE I.

Year.	Amount produced.				Average price per ton obtained on the plantation.
	Tons.	Cwts.	Qrs.	Lbs.	£ *s.* *d.*
1927-28	22	11	2	11	17 19 4
1928-29	51	15	1	1	17 13 0
1929-30	89	4	1	13	14 19 3
1930-31	101	3	0	26	12 0 5

It will be noted that there has been a steady decline in prices received. This fall is, of course, due to the fall in prices in England, and is not due to any deterioration in the quality of copra produced. This is shown by the fact that in the year 1930–31, 93.7 per cent of the copra sold was first grade, and 6.3 per cent second grade.

It is estimated that production, when the plantation is in full bearing, will be about 120 tons of copra per annum.

EXPERIMENTS WITH "TYPE" NUTS.

As stated in Paper No. XXIV of the 1928 Year-Book, p. 186, it is highly desirable that only nuts from the best variety of palm available should be planted. Work in connection with the selection of a type giving yields above the average has been continued, and the results obtained are shown in Table II.

TABLE II.

Type Nut.	Number of nuts dealt with.	Copra obtained lbs.	Number of nuts required per ton copra.	Number of nuts required per ton (whole plantation.)	Gain on plantation average.
"A"	12,000	4,889	5,498		457
"B"	12,000	5,226	5,144		811
"C"	5,000	2,092	5,354	5,955	601
"D"	12,000	4,638	5,795		160
"E"	10,000	4,328	5,176		779

It will be noted that each of the types show a gain in nuts required to make a ton of copra as compared with the average of the whole plantation—type "B" showing the greatest gain. Nuts of this type are being used for distribution.

With a view to ascertaining whether there is any marked difference in the average number of nuts borne per palm by the different types, records of collections during the last six months have been kept, and are shown in Table III.

TABLE III.

Type Nut.	"A."	"B."	"C."	"D."	"E."
Average number of nuts borne per palm, six months period.	34	28	38	28	27

INVESTIGATION TO DETERMINE IF AND WHEN, DURING THE YEAR, THERE IS A PERIOD OF GREATEST YIELD.

In the case of many permanent crops, cacao, for example, there is a well-defined crop season. This is not the case with coconuts; nuts are ripening all the year round. It is quite possible, however, that the yield does fluctuate to some extent at different seasons of the year, and with a view to obtaining information on this point investigations were commenced in 1929.

For the purpose of the experiment five rows of palms were selected. Care was taken to ensure that conditions were as uniform as possible. The palms were practically all in full bearing at the time the experiment was commenced, and there are no palms bearing type nuts among them. The rows selected are numbers 135 to 139, and they are on the south side of the central path through the plantation. The nuts are allowed to fall naturally. The fallen nuts are collected on the last working day of each month, counted, and the records entered. Results to the time of writing are shown in Table IV.

TABLE IV

Month.	Number of nuts collected from Row No.					Total for month.
	135.	136.	137.	138.	139.	
1929.						
September ..	52	83	103	76	134	448
October ..	73	49	67	64	60	313
November ..	68	55	83	52	66	324
December ..	109	77	93	82	86	447
1930.						
January ..	85	91	78	77	73	404
February ..	118	105	101	103	129	556
March	199	166	172	142	108	787
April	217	151	216	134	251	969
May	181	184	199	143	224	931
June	170	134	168	116	158	746
July	150	161	201	153	175	840
August	153	114	144	160	141	712
September ..	97	132	187	151	171	738
October ..	102	123	135	151	142	653
November ..	85	91	58	102	87	423
December ..	156	119	152	100	100	627
1931.						
January ..	140	116	106	125	85	572
February ..	100	61	114	100	115	490
March	132	101	150	114	120	617
	2,385	2,113	2,527	2,145	2,425	11,597 nuts.

Average number of nuts per month from the five rows, 610.

YIELDS FROM TWO ACRE PLOT.

As the palms in the five rows referred to previously occupy two acres of land, the plot is also used for the purpose of keeping records of yields per acre in that part of the plantation.

The yield of nuts during the first complete year of the experiment was 7,477, or 3,738 nuts per acre per annum. From these nuts 2,921 lbs. copra were obtained, equivalent to 13 cwts. 4 lbs. of copra per acre per annum.

THE INCIDENCE OF MOULD ON COPRA.

This subject was dealt with in Paper No. XXX, " Moisture and Mould in Copra, Western Province," of the 1929 Year-Book, pp. 233–238.

The work has been continued, and a further 29 lots have been under observation. Records kept show that a growth of greyish-green mould develops in an average period of 103 days. This mould (*Penicillium* sp.), may, however, be considered as harmless. It is reported as often occurring on Ceylon copra, and is not considered detrimental if the incidence is mild, as is the case with Atwabo copra.

It may now be taken as established that well-dried copra may be safely stored in Nzima for some length of time, probably three months in the rainy season and longer in the dry season, provided, of course, that it is kept in a properly constructed and well ventilated store.

Well-dried copra may be defined as copra which represents not more than 59 per cent by weight of the original fresh kernel.

INCREASE IN WEIGHT, BY THE ABSORPTION OF MOISTURE, IN STORED COPRA.

It has been found that well-dried copra increases in weight to some extent by the absorption of moisture during storage—*vide* pages 236 and 237 of the 1929 Year-Book. It was at one time thought that sufficient moisture might be taken up to allow pernicious moulds to grow on it but this has been shown not to be the case.

Records of weight kept of 29 lots during 1930–31 show that the weight fluctuates according to the season, in other words, stored copra takes up moisture during damp weather and parts with it again during dry weather, but there is no record of a sample of initially well-dried copra taking up sufficient moisture to enable bad moulds to grow on it. The aim in storing copra should therefore be to store it in a building made as damp proof as possible.

This subject is dealt with more fully in Paper No. XXX of the 1929 Year-Book.

RATIO OF COPRA TO KERNEL.

The drying of separate 100 lbs. lots of kernel, commenced in July, 1928, in order accurately to determine the ratio of well-dried copra to kernel, has been continued. Twenty-nine such lots were dried during 1930–31. The mean weight of copra from these lots was 58.27 lbs.

A total of 397,066 lbs. of kernel were dealt with at the plantation during the year 1930–31. 226,602 lbs. of copra were obtained from this amount of kernel, or 57.6 per cent.

COPRA-MAKING.

The amount of copra produced during the year was 101 tons, 3 cwts. 0 qrs. 13 lbs. This is the first year that the output has been 100 tons and over.

The cost of making this copra was £503 10s. 6d. or £4 19s. 7d. per ton. Details of cost are shown in Table V.

TABLE V.

	£	s.	d.
Collecting nuts	79	7	6
Cutting out kernel, and transport to dryers ...	104	2	10
Drying	169	19	4
Bagging, etc.	14	9	7
Collecting fuel, stands for drying on, etc. ...	115	0	9
Transport of copra to buyer's store	8	17	2
Sacks	11	13	4
Total	£503	10	6

RECORDS OF NUTS DEALT WITH, AND RESULTS.

Table VI shows the number of nuts dealt with and results during the year 1930–31.

TABLE VI.

Nuts split.	Number useless.	Number used for copra.	Weight of kernel tons.	Weight of copra tons.	Number of nuts per ton of copra.
613,388	10,940	602,448	177.26	101.16	5,955

The relative percentages are as follows :—

	1930–31.	1929–30.
Useless nuts	1.78 per cent	5.19 per cent.
Ratio kernel to sound nuts ..	65.90 per cent	65.00 per cent.
Ratio copra to kernel	57.06 per cent	59.94 per cent.
Number of sound nuts per ton of copra	5,955	5,946

CENSUS OF PLANTATION.

A recently taken census of the plantation revealed the following figures :—

Palms bearing " Type " nuts :—

" A " type	129
" B " type	212
" C " type	78
" D " type	107
" E " type	64
Total palms bearing type nuts ...	590
Palms not bearing type nuts, in full bearing	9,446
Young palms, commencing to bear ...	548
Young palms, not yet bearing ...	2,868
Vacancies	523
	13,975

Many of the vacancies are in places bordering on the swampy area north of the plantation, where conditions are not favourable for the growth of coconut palms.

The effective area of the plantation may be estimated at 241 acres.

PLANTATION COSTS—ITEMISED.

The itemised costs of the plantation for the year April, 1930 to March, 1931, are shown in Table VII.

TABLE VII.

	Cost.					
Plantation upkeep and nurseries.	£	*s.*	*d.*	£	*s.*	*d.*
Cutlassing	117	6	9			
Filling vacancies	5	7	9			
Collecting coconuts for seed ...	7	7	3			
Nursery at plantation	13	12	3			
Nursery at Bonyere, including transport of seed there	27	17	9			
Grubbing stumps	6	0	0			
Fencing	13	11	6			
				191	3	3

TABLE VII.—*continued.*

Harvesting nuts and preparing copra.								
Harvesting nuts				79	7	6		
Preparing copra				424	3	0		
Repairs to dryers				19	19	3		
New dryer				31	12	7		
Small dryers				3	6	0		
Mats for drying, and tie-tie ...				6	17	3		
Materials—cement, etc.				55	6	2		
Temporary buildings				2	13	4	623	5 1
New tramway				156	13	9	156	13 9
Miscellaneous expenditure.								
Watchman				9	3	6		
Sanitation				22	2	8		
Messenger				4	11	6		
Peppercorn rent				0	1	0		
Well and pump				11	1	2		
Enclosure for meteorological instruments				1	9	9		
Agricultural survey				1	8	6		
Bungalow				4	17	1		
Carpenter and mason				9	1	9		
Unclassified				25	2	4	88	19 3
Total							£1,060	1 4

The revenue for the same period amounted to £1,372 14s. 9d.

PAPER No. XVIII.

DEVELOPMENTS IN THE COCONUT INDUSTRY IN NZIMA.

By W. C. FISHLOCK.

THE INTRODUCTION OF THE COCONUT PALM IN NZIMA.

Though, no doubt, the coconut palm is an introduced plant in Nzima, no very precise information is available as to the time of its introduction, or from whence it was brought to this part of Africa. There is, however, a tradition to the effect that seed nuts were first brought to Nzima from the vicinity of Bonuah, in the French Ivory Coast. It is said that the inhabitants of neighbouring villages regularly went to Bonuah for the purpose of making salt and palm oil, and, finding good water scarce there, but coconut palms growing plentifully, used the water from the nuts for drinking, and carried away the seed nuts for planting elsewhere. However this may be, prior to the establishment of a coconut plantation at Atwabo, small groves of coconut palms existed at nearly every village along the beach from Newtown to the mouth of the Ankobra.

ESTABLISHMENT OF THE COCONUT PLANTATION AT ATWABO.

In 1919 Government decided to establish trial coconut plantations in the Western, Central and Eastern Provinces, and an area of land lying between the town of Atwabo and the village of Anochi, about 25 miles west of Axim, was selected as the site for the plantation in the Western Province. The land is held under a lease from the Stool of Eastern Nzima.

PROPAGANDA WORK.

From the very commencement of work in establishing the plantation, down to the present time, propaganda work has been carried on in all the towns and villages of what may be termed the coconut country. This propaganda work had small effect till the people saw the palms bearing in the plantation, and copra being made and sold.

A census of the farms in the area, taken recently, shows that of 111 farms which have been planted since the commencement of work at the Government plantation, only 14 are more than three

years old. It is thus clear that by far the greatest amount of planting has been done since the plantation came into bearing. It would appear that the farmers, before planting to any considerable extent themselves, waited to see what measure of success attended the Government plantation.

AREAS OF LAND AVAILABLE.

It is estimated that, from the mouth of the Ankobra to Newtown, a distance of about 60 miles, there are 15,000 acres of land well suited to the cultivation of coconuts. Some of this land is at present used for the growing of cassava, groundnuts, and a gourd called "*ngatia*," but much of it is still under rough scrub. This land is not well suited for the growth of cassava, which could be more successfully grown further inland. Groundnuts and *ngatia* both grow well on it, but there is plenty of land available further inland equally well suited for their growth. There is little doubt that they could more profitably be replaced by coconuts on this sandy strip of country near the beach.

Taking the average yields quoted by Pobee in his paper "The Groundnut Industry of Nzima" (Paper No. XXVI of the 1929 Year-Book, pp. 213–217), it appears that the gross annual return per acre from groundnuts is £6. At present local prices for copra (£11 per ton), and on the basis of yields obtained from the areas of the plantation in full bearing, the gross return from copra is about £5 10s. per acre per annum. Groundnuts are an annual crop, and entail much labour every year. On the other hand, coconuts are a permanent crop and, once established, the annual labour needed is small in comparison. The advantage, therefore, appears to lie with coconuts.

Apart from the sandy ridge near the beach, there is a large area of land further inland which is well suited to the cultivation of coconuts.

SUITABILITY OF THE LAND FOR COCONUTS.

Behind the sandy ridge already alluded to, there is a large area of low-lying, swampy country, intersected with streams and fresh water lagoons.

This water is continually flowing out to sea under the sandy ridge. In many of the small towns and villages along the ridge, wells have been sunk in the sand, and, at depths varying with the height of the ridge at the spots where the wells are sunk, abundant supplies of water are obtained. For instance, quite recently in the plantation a well was dug, and an abundant supply of excellent water was obtained at a depth of seven feet.

This underground water percolating out to sea, combined with a light sandy soil, heavy rainfall, and maritime conditions,

i.e. a salt atmosphere, caused by spindrift from the continual surf, provides a set of conditions well-nigh ideal for the cultivation of coconuts.

THE SUITABILITY OF THE INDUSTRY TO THE PEOPLE.

It is a fortunate circumstance that the coconut industry fits in admirably with the ways of life of the people of Nzima. This fact will make the development and expansion of the industry much easier than would otherwise have been the case.

The bulk of the people of Nzima have not been accustomed to prolonged periods of hard work. It is true that many of them formerly worked in the timber industry, but, in the prosperous days of that industry, a man worked hard for a part of the year, earned plenty of money for his work, and returned to his town or village to live in ease for the remainder of the year.

The cost of establishing a coconut farm in Nzima, so far as the local farmer is concerned, is small. The method may be briefly described as follows : An area of land is taken, it may be covered with bush and rough scrub, and the clearing of this bush requires a certain amount of work and possibly some small expenditure for hired labour. The land is then lined and the coconut palms planted. The lining and planting is most likely done by the farmer himself, or, at all events, at small cost.

After the palms are planted, women cultivate the land between them, planting groundnuts in April and harvesting them about September. This crop is followed by a crop of *ngatia*, the seeds of which are used for soup. The gourds are harvested about January, and the land is left fallow till April, when it is again prepared for groundnuts. This process of cropping the land between the growing palms is continued till the palms cover the land. Sometimes the women pay a part of their crop to the owner of the land ; in any case the coconuts are established at very little cost.

Once the palms come into bearing, i.e. in about five to six years from the time of planting, little labour is required to keep the farm clean, and the labour required to collect the nuts, extract the kernel and convert this into copra is comparatively small, and would probably be done chiefly by women and children. Unlike cacao, the pods of which must all be gathered and dealt with in a comparatively short space of time, the nuts may be allowed to accumulate and be dealt with as convenient. So long as they are kept under a rough shed, they may be stored for two or three months with little or no deterioration.

It is thus an industry well suited to a people who have not been accustomed to prolonged steady work, and promises an easy mode of life for the farmers of Nzima.

DEMAND FOR THE PRODUCT.

There is usually a good demand for copra, for the sake of the edible oil which it contains. This oil, or fat, as it becomes in a cool climate, is used very largely in the making of substitutes for butter, and to some extent in the making of high-grade soaps. The fact that the copra is produced near the sea, and thus has not to bear heavy land transport charges to a point of shipment is greatly in its favour. It can thus compete on favourable terms with oil-bearing nuts and seeds produced many miles inland.

PRESENT STATE OF THE INDUSTRY IN NZIMA.

A census of the farms in the area has recently been made. Results are shown in the following table :—

TABLE I.

Name of Village.	Number of farms.	Number of palms planted.	Area of farms, in acres.	Source from which planting material was obtained.	
				Plantation.	Other.
Esamang	1	2,000	28½	—	2,000
Asemko	1	336	5	—	336
Kickham	24	14,902	217	—	14,902
Esiama	8	2,890	39¾	—	2,890
Mpein	1	338	3	—	338
Sensuri	2	331	3½	—	331
Krisan	3	246	2¼	—	246
Eikwe	3	1,163	18½	—	1,163
Beku	1	210	2	—	210
Anochi	2	880	15	880	—
Atwabo	15	5,556	76¾	5,556	—
Beyin	6	7,784	110½	100	7,684
Nuba	4	3,800	54½	3,800	—
Aloen	2	483	7	—	483
Kangan	4	868	9	221	647
Twenani	2	541	4½	—	541
Ajesa	1	133	1	—	133
Alanganzure ..	1	300	4½	—	300
Alawuri	2	561	8	—	561
Sinibo	1	210	1	—	210
Bonyere	6	3,431	32½	840	2,591
Bukakure	1	1,200	17	1,200	—
Atwibanso ..	4	295	1½	—	295
Epun	10	8,700	88¼	—	8,700
Half Assini ..	6	6,800	96¾	5,950	850
	111 farms	64,938 palms	847 acres	18,547	46,391

NOTE.—The palms are not all planted at the correct distance apart, *viz.* 30′ × 25′. If all were planted at that distance, the acreage would be 1,119.

A map, indicating the distribution of the farms, is appended.

DISTRIBUTIONS OF PLANTING MATERIAL.

During the last four years 27,690 seed nuts and seedlings have been distributed from the plantation, or sufficient to plant 477

acres of land. Considerable supplies of planting material have, however, been obtained from other sources.

With a view to facilitating the distribution of planting material, and to make it easier for farmers to obtain supplies, a nursery has been started at Bonyere, mid-way between Atwabo and Half Assini, and it is planned to establish a nursery at or near Asanta in the near future. The transport of planting material from the Atwabo Plantation to the sites of farms has hitherto been difficult and expensive for the farmers. By making nurseries at convenient places this difficulty and expense will be to a great extent removed.

MARKETING THE COPRA.

At the present time only a small quantity of copra is being produced outside the plantation, only a few of the privately-owned farms having reached producing stage. All the copra produced in the area so far, has been purchased by a firm doing business locally.

Steps are being taken to form co-operative societies of the growers, with a view to dealing effectively with the copra they produce, and to ensuring that none but good grade copra is shipped. Copra at present produced in Nzima commands a higher price than that produced in the eastern parts of the Colony, and it is highly desirable to maintain a high standard of quality.

POSSIBLE FUTURE EXTENSION OF THE INDUSTRY.

Assuming that the readily available area near the beach is planted up, and that the industry is firmly established there during the next few years, there then arises the question of further extension.

Whilst the country inland of the swampy area referred to previously is probably not so ideally suited to the cultivation of coconuts as the sandy ridge near the beach, there is reason to believe that considerable areas of land quite well suited to the crop, probably 20,000 acres or more, are to be found within ten miles inland from the beach. It is also probable that the climate thus far inland is sufficiently maritime to enable the palms to flourish and bear good crops of nuts. As an indication of this, promising farms have been established at Nuba, six miles inland.

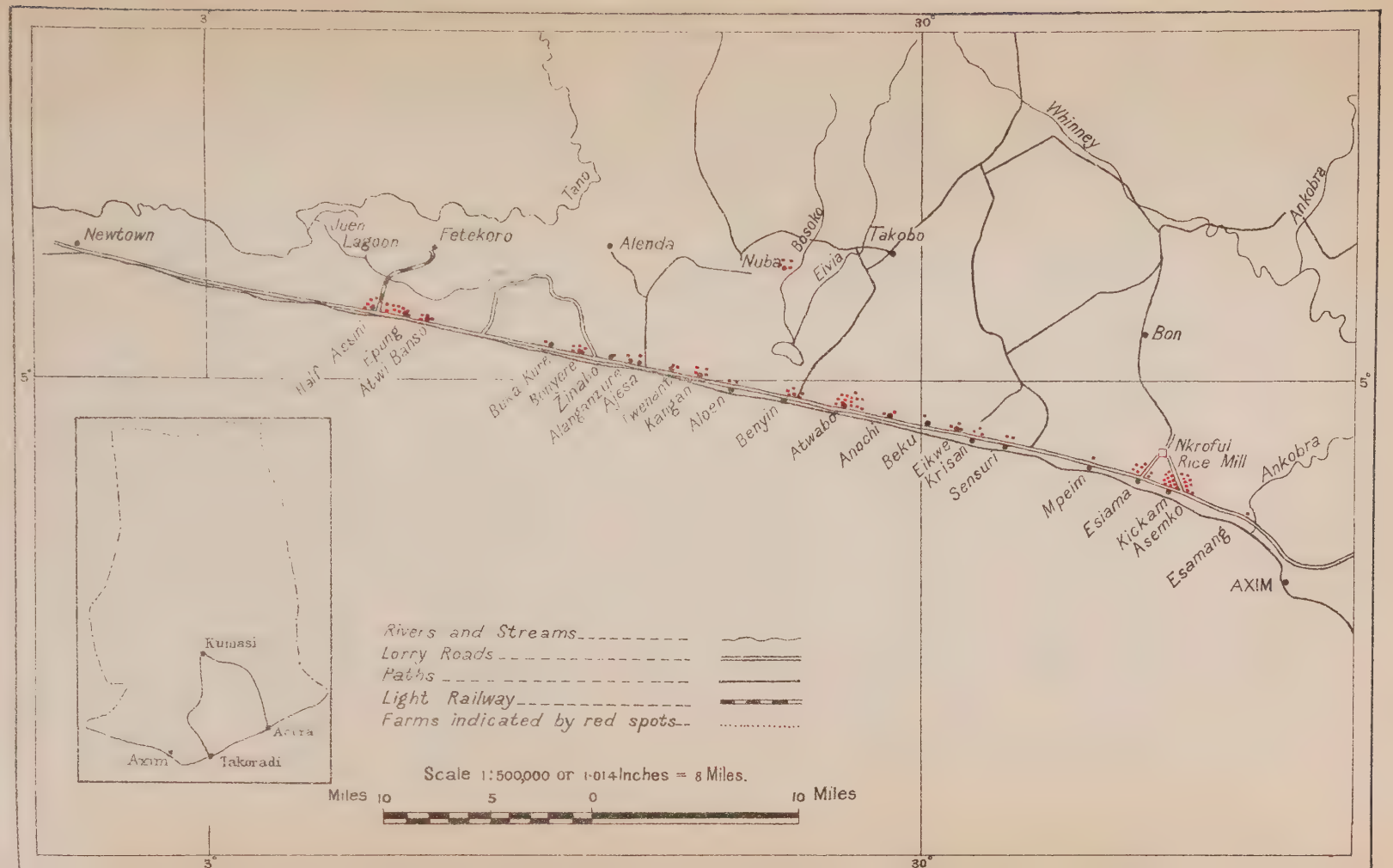
Assuming that 20,000 acres of land suitable for the crop are to be found inland, that area, added to the estimated 15,000 acres near the beach, would give an area of 35,000 acres or more, with a potential output, based on yields obtained at the plantation, of about 15,000 tons of copra per annum.

The question of population to deal with such a considerable development of the industry naturally arises, and it must be said that at present there would not be sufficient people available to

develop it to that extent. On the other hand, with the opening up of the country inland, and the starting of such an industry, there is no doubt many people would come into the area, and also many of the people who, from the absence of industries, have drifted away, would doubtless return.

Having in view the decline of the timber industry, and the fact that no exportable agricultural product is produced in quantity in the area, the people of Nzima would be well advised to extend the industry as much as possible, for without doubt they would find a large industry in coconuts and copra of great value to their country.

DISTRIBUTION OF COCONUT FARMS IN NZIMA



PAPER No. XIX.

A SURVEY OF THE COCONUT AREA IN THE KETA-ADA DISTRICT.

By C. L. SKIDMORE and J. S. MARTINSON.

INTRODUCTION.

A survey of those areas under the coconut palm in the Keta-Ada section of the Eastern Province was carried out by Mr. Martinson and staff from April, 1929 to November, 1930 ; the object of the survey having been to obtain definite quantitative information on which to base recommendations for the future agricultural policy of the district.

Although approximately 1,300 tons of copra are exported from the ports of Keta and Ada each year, probably rather more is used for internal consumption in the area, whilst a certain number of nuts are disposed of by sale in other Eastern Province towns and villages. It will be thus realised that though the export figure is low, it is but a small indication of the importance of an industry which is a vital one to the inhabitants of the area.

TOPOGRAPHY.

Keta and the surrounding area is situated in the south-eastern corner of the Colony and is characterised by a low rainfall—the average for the last 10 years being 32.14 inches with a mean of 45 wet days per year. It is further unusual in that there is a narrow coastal strip separated from the hinterland by a salt lagoon which is at times dry. The cultivation of palms in this strip is confined to a narrow belt some 50 miles long and varying in width from 50 to 500–600 yards.

NOTES ON THE AREAS DEALT WITH.

Before proceeding further, it will, perhaps, be as well to describe the main features of the areas under which the statistics collected have been grouped. In reality, there are two belts :—

(1) The coastal belt from Atititi to Aflao.

(2) The hinterland belt lying behind the coastal belt and the lagoon.

For the examination of the statistics each of these two belts has been divided into two—the coastal belt resulting in two narrow

strips, Atititi to Voja, and Keji to Aflao; whilst the hinterland belt has been arbitrarily divided at Seva into *Hinterland A* and *Hinterland B*, both of which are discussed later.

The Coastal Belt.

Atititi to Voja.

The soil along the littoral is poor consisting practically of pure sand, whilst the lagoon, when dry, is composed of thick mud unsuitable for the growth of coconut palms. Its edges are, however, used for the raising of seedlings in nurseries. The principal industry of the area is fishing, and owners of farms are mostly boatmen or fishermen. This has resulted in a neglect of the farms which are found unevenly distributed along the belt and in which the palms appear vigorous only near the villages.

Keji to Aflao.

The strip from Keji to Aflao is very narrow at the southern end, but gradually widens towards the frontier—the width varying from 420′ to 12,000′. Along its whole length there is a continuous belt of palms which appear healthier than those in the former strip. Farming practice is on a higher level, involving, as it does, the use of catch crops, surface hoeing, drainage and water conservation. The soil improves as one proceeds towards the Eastern Frontier and it is around Aflao that some of the best plantations occur.

The Mainland Belt.

Aferingba to Akame.—Hinterland A.

From Aferingba through Agbosome to Akame in the north-eastern section is found the best belt in the district and the soil, though sandy, is relatively rich and has been improved by cultivation. The palms are planted regularly and at reasonable distances, whilst on nearly every farm cattle are kept whose manure is applied to the farms. The inhabitants, unlike those of the coast who are mainly interested in fishing, are farmers, i.e. they rely on their farms for their livelihood and, in consequence, the growing of food-crops is pursued with some assiduity.

Seva to Baive.—Hinterland B.

The western section of the hinterland belt is considerably broken by marshy ground unsuitable to the successful growth of coconuts. Apart from these patches, the soil is very rich, well-watered and grows coconut palms excellently, although this same richness tends to make the farmers there care rather more for food-crop than coconut-farming.

DATA COLLECTED.

Information as to yields and boundaries was obtained from the farmer himself who accompanied the overseer to the farm. Areas were then ascertained approximately by pacing. The owner

was classified as male or female, and counts were made of the number of palms fruiting, barren, and young, and also the number of nuts required to furnish a bag of copra—a bag in Keta weighing 140 lbs. Additional data collected were the number of adults, children and compounds, and an estimate of the number of bags produced per farmer. Extreme accuracy in a survey of this magnitude is impossible, but, owing to the staff and to the areas covered, the errors will for the most part be compensating.

The accompanying Table I gives figures, both actual and calculated, for the four areas, and embraces all the detailed records made during the survey. In this table, young palms are palms under five years old and are non-fruiting. Barren palms are adult palms which were observed to be non-fruiting at the time the survey was carried out. The number of bags produced was estimated by the farmer himself and may be somewhat in excess of the actual owing to the use of round numbers. In the vital statistics, a child is a person of 13 years or under, whereas an adult is over that age.

EXAMINATION OF THE STATISTICS.

From the table it is seen that 3,112 tons is the estimate of copra produced from the whole area, made up of 1,890 tons from the coastal strip Atititi to Aflao, 1,195 tons from the area Aferingba to Akame and a negligible amount (27.5 tons) from around Seva and Hatagudo.

The following table gives the copra exports from Keta and Ada for the last eight years together with the total maritime exports from the Colony* :—

	Ada.	Keta.	Total Keta-Ada.	Total Export (Colony).
1923	58	1,600	1,658	1,659
1924	43	1,106	1,149	1,152
1925	25	1,295	1,320	1,323
1926	17	1,492	1,509	1,512
1927	5	1,446	1,451	1,454
1928	5	1,403	1,408	1,456
1929	11	1,158	1,169	1,236
1930	27	799	826	917

Keta and Ada thus export 98 per cent of the total whilst their mean annual export is 1,311 tons. The export of coconuts from Keta and Ada which rose from 41 in 1923 to 18,790 in 1924 has since been negligible, the mean annual number exported for the last six years being 932. If, therefore, the estimate of production is correct, approximately 42 per cent is exported, the remaining 58 per cent being consumed locally. From the amount offered for export a deduction must be made for the additional drying this

*Figures taken from the Blue Book.

receives together with the waste that must take place owing to the lots offered for sale being composed in part of defective low quality copra.

Looking at the table it will be seen that the strip from Atititi to Voja as compared with the strip Keji to Aflao has a smaller number of farm owners, 1,974 acres under coconuts as against 4,000, and a production of 594 tons of copra as against 1,300 tons. The lower out-turn of copra has other contributing factors which the table brings out, viz., a lower percentage of yielding trees, whilst 22.6 per cent of the farm-owners as against but 3.5 per cent owned farms at the time of the census, which gave no yield at all. Additional reasons not brought out by the figures are the interest taken in fishing and the poorer soil of the strip Voja to Atititi.

Comparing the two main producing areas—the coastal belt and *Hinterland A* (Aferingba to Akame) it will be seen that though the latter has but a third of the population of the former yet 43 per cent of the adults own farms as opposed to 16.5 per cent on the coast. As remarked earlier, farming in the hinterland is the means of livelihood and the figures bring this our very clearly with the high production per head of the population of 267.8 lbs. of copra. The mean size of holding, the percentage of fruiting palms, and the yield per acre are similar in both areas ; the difference in the two areas being the large proportion of the adult population engaged in the industry.

The area around Seva and Hatagudo offers a likely field for extension. That the native appreciates this is shown by the high percentage of young non-fruiting palms. The yield from this area will increase in future—at present food-crop farming is the principal industry but there is evidence of the tendency to grow more coconut palms.

Table II gives the principal towns and villages in each area under which the field records were entered. It also gives an estimate of the number of bags of copra produced from and around each centre.

NOTES ON THE COCONUT INDUSTRY

Cultivation.

Many coconut farms along the coast, are neglected by their owners. This coupled with the poor soil is reflected in the high percentage of barren trees. Where attention is paid to the farms, they are weeded, dug and manured. On the mainland around Agbosome, cattle-dung and house refuse are applied whilst along the coast, fish, bat manure and house refuse are used. In some cases cattle-owners lend their cattle to farmers who own no cattle, who, in return for the dung left on the land, give occasional free labour to the stock owners. The method of applying the manure is a poor and wasteful one, as it is often left on the surface of the

ground for a considerable length of time, or until the rainy season, before being hoed in. Mulching is rare owing to the scarcity of mulching material.

Harvesting.

In general, harvesting takes place four times a year and the nuts are gathered when not fully ripe, heaped and left for some time. In the mainland the nuts are allowed to drop or are picked only when fully ripe.

Preparation of Copra.

Usually nuts from the previous picking are split and the copra spread on the bare sand or on coconut leaves. The copra as a rule is imperfectly dried, left uncovered at night and afterwards badly stored. Badly dried copra is frequently offered for sale owing to the need for ready cash.

Oil-making.

The census staff estimated that from one-third to three-eighths of the copra produced is used for the extraction of oil. In the mainland belt around Agbosome, quite half of the nuts are sold locally for oil-making. This copra may be sold (as at Tegbi) to native oil-preparers or the oil may be extracted by the farm-owners themselves and sold in the local markets (as at Atokaw) where it fetches about 2s. to 3s. a gallon.*

Sale of nuts.

In addition to the daily consumption of fresh nuts as food and drink and the use of nuts and copra for oil extraction, a considerable trade is carried on in the despatch and sale of nuts to up-country markets. The amounts disposed of under these three headings must be allowed for in estimating that quantity of the total production which is available for export.

As remarked earlier, the number of nuts exported annually has, since 1924, been negligible.

Diseases and Pests.

Root-rot, bud-rot and stem-bleeding occur throughout the area but the damage is not large and no serious attention is paid to any disease save root-rot which is treated, after the disease has shown above ground, by burning.

The Rhinoceros beetle is present but is uncommon whilst scale insects are plentiful.

THE ADA DISTRICT.

The Ada coconut areas were not surveyed in detail. Inspection showed that there is one belt of coconuts running along the coast between Ada and Pute. The farmers do not prepare copra but sell the nuts locally. The soil is good and the trees healthy.

*At the time of going to press the price has dropped and is now from 1s. to 1s. 2d. per gallon.—Editor.

AREAS SUITABLE FOR EXTENSION.

Along the coastline, the areas available for planting with coconuts are limited. Extension is possible from Jita to Wuti, from Awunaga to Dzelukofe, around Denu, Avoeme, Aflao and in the Ada area.

On the mainland in *Hinterland A*, extension is in progress at Glidji and a small area could be utilized at Tegey but it is to *Hinterland B* that one must look for larger areas capable of growing coconut palms. Around Achavi and for five to six miles north of Hatagudo and Baive the ground water supply is moderately good, and the soil, where it is not swampy would grow coconuts excellently.

Throughout the whole area the coconut farms could be extended inasmuch as gaps and small areas between farms could be planted up.

TABLE I.

COCONUT SURVEY—KETA-ADA DISTRICT—SUMMARY OF CENSUS DATA.

	Coastal Strip.					
	Atititi to Voja (*a*)	Keji to Aflao (*b*)	Coastal Strip Atititi to Aflao (*a* + *b*)	Hinterland A Aferingba to Akame.	Hinterland B. Seva to Baive.	Totals or Means.
Compounds	1,539	1,187	2,726	1,021	511	4,258
Population	19,365	13,964	33,329	9,994	3,539	46,862
Number of adults	10,686	8,608	19,294	4,775	1,860	25,929
Number of children	8,679	5,356	14,035	5,219	1,679	20,933
Number of males owning farms	1,703	1,353	3,056	1,979	110	5,145
Number of females owning farms	77	41	118	76	2	196
Total number owning farms	1,780	1,394	3,174	2,055	112	5,341
Percentage of farm owners to adults	16.7	16.2	16.5	43.0	6.0	20.6
Acreage under coconuts	1,974	4,000	5,974	3,734.5	136	9,844.5
Mean size of holding	1.1	2.9	1.9	1.8	1.2	1.8
Quantity of copra produced in lbs	1,330,070	2,903,810	4,233,880	2,676,170	61,670	6,971,720
Number of males with fruiting palms	1,320	1,305	2,625	1,723	95	4,443
Number of females with fruiting palms	58	40	98	68	2	168
Total farmers with fruiting palms	1,378	1,345	2,723	1,791	97	4,611
Total number of fruiting palms	112,556	257,475	370,031	232,227	6,172	608,430
Number owning farms with no fruiting palms	402	49	451	264	15	730
Percentage of farmers having no fruiting palms	22.6	3.5	14.2	12.8	13.4	13.7
Lbs. of copra per fruiting tree	11.8	11.3	11.44	11.52	10.0	11.3
Production in lbs. per head of farmer with fruiting palms	965	2,159	1,555	1,494	636	1,511.9
Number of fruiting palms per farmer	63	185	117	130	55	114
Number of fruiting palms per acre	57	64	61	62	45	62
Production in lbs. per head of the population	68.7	208	127	267.8	17.4	148.8

TABLE I—*continued.*

COCONUT SURVEY—KETA-ADA DISTRICT—SUMMARY OF CENSUS DATA.

	Coastal Strip.		Coastal Strip Atititi to Aflao ($a + b$).	Hinterland A Aferingba to Akame.	Hinterland B Seva to Baive.	Totals or Means.
	Atititi to Voja (a)	Keji to Aflao. (b)				
Yield of copra in tons	593.8	1,296.3	1,890	1,194.7	27.5	3,112.2
Percentage of copra produced by each area	19	41.7	60.7	38.4	.9	33.3
Yield in cwts. per acre	6.0	6.5	6.3	6.4	4	6.2
Number of barren palms	53,362	63,408	116,770	18,232	191	135,193
Number of young non-fruiting palms ..	58,621	67,439	126,060	103,359	4,687	234,106
Total palms (all 3 classes)	224,539	388,322	612,861	353,818	11,050	977,729
Percentage of barren palms	23.8	16.3	19.1	5.2	1.7	13.8
Percentage of young non-fruiting palms ..	26.1	17.4	20.6	29.2	42.4	24.0
Percentage of fruiting palms	50.1	66.3	60.3	65.6	55.9	62.2
Total number of palms per acre	114	97	103	95	81	99
Corresponding to a spacing of	19.5′ x 19.5′	21.2′ x 21.2′	20.5′ x 20.5′	21.4′ x 21.4′	23.2′ x 23.2′	21′ x 21′
Number of nuts per load	472	476	474	538	461	491
Number of nuts per lb. of copra	3.4	3.4	3.4	4	3.3	3.6

TABLE II.

Copra Production.

(1 bag = 140 lbs)

COASTAL BELT. (*a*) Atititi to Voja.		HINTERLAND A. Aferingba to Akame.	
Centre.	Number of bags produced.	Centre.	Number of bags produced.
Atititi	112	Aferingba	2,072.5
Jita	1,544.5	Ayidiga	15
Atokaw	438	Tegey	240.5
Srogbwe	197	Akaglakofe	500.5
		Tamaklokofe	1,194
Wuti	284	Aveta	687
Awunaga	985	Glidji	625.5
Abutcha	18.5	Sohume	559.5
Weh	1,004	Dogbuikofe	370
Tegbi	2,764	Avloto	219
Vui	432.5	Datekofe	1,006.5
Dzelukofe	998	Afuta	1,350
Keta	580	Agotome	313
Voja	143	Sonto	2,439
		Amafinukofe	3,761
Total	9,500.5	Kumadekofe	13,46.5
		Nogokpo	1,035
		Akame I	645
		Akame II	736
		Total	19,115.5
(*b*) Keji to Aflao.			
Keji	1,045.5		
Blekuso	1,455.5		
Agavedji	307	HINTERLAND B. Baive to Seva.	
Amutinu	246		
Adina	709	Baive	8
Adafienu	4,106.5	Hatagudo	307
Hedjeranawa	691.5	Betuinu	14
Denu	4,068.5	Achavi	21.5
Viefe	967.5	Fenyikaw	4
Avoeme	1,925.5	Wenuga	29
Aflao	5,219	Seva	57
Total	20,741.5	Total	440.5

PAPER No. XX.

COTTON DEVELOPMENT, 1930-31—TAMALE INVESTIGATIONAL STATION.

By J. E. SYMOND and T. L. WILLIAMS.

At the conclusion of the previous season three promising strains had been isolated by selection work. Two of these, T66 and T57, were somewhat impure, especially in their seed characteristics, and the third, D28, was considered practically pure. The first two gave higher yields than the third, and their highest yielding individual plants approached most nearly to the flowering curve demanded by the climatic conditions of the Northern Territories.*

It was decided to make small-bulk trials of these three strains with such amounts of seed as were available, the most promising individual plants being retained for further selection work and purification. New varieties were to be tested, including Asiatic cottons and trials made with artificial fertilizers.

This report will be divided into the following sections :—

I. Result of small-bulk trials with selected strains.
II. Further selection and breeding work.
III. Physiology and disease.
IV. Other varieties tested during the season.
V. Trials with artificial manures.
VI. Cotton in rotation trial.

PART 1.

RESULT OF SMALL-BULK TRIALS.

In the two impure strains T66 and T57, smooth and semi-fuzzy seeded types were separated from fuzzy-seeded. It was expected from the previous season's work that the fuzzy-seeded was recessive and would breed true this season. This has been the case, but the manner in which the smooth-seeded types have split up indicates that the inheritance of this character is more complex than was supposed.

The planting distance was 4′ × 1′ and the cotton grown on ridges. The planting date for the first four strains in the table below was 9th July, and 15th July for the fifth. Table I below gives the yields from these strains.

*For details of previous work see Papers XXXV and XXXVI, Year-Book 1929.

TABLE I.

Strain.	No. of Plants at time of flowering.	Percentage rogued.	Yield per acre-lbs seed cotton.	Shedding percentage.
T66 smooth	1,875	11	70	81.0
T66 fuzzy	520	15	100	79.2
T57 smooth	1,428	14	92	76.5
T57 fuzzy	430	4	106	80.3
D28	2,787	16	181	64.7

In considering the above yields, due allowance must be given to a very low seeding rate per acre (3-4lbs.) which was necessary owing to the small amounts available, and the rogueing has not been taken into account in computing yield. In spite of this, however, the strains T66 and T57 are disappointing (their previous calculated yields being 253 and 166 lbs., per acre respectively) and it has become apparent that considerable further purification is necessary. As shown in the following section of this report, various individuals of these strains retain their comparatively high yield, and it is not considered desirable to proceed with bulk trials till these are fixed. In view of the complex inheritance among the smooth-seeded types, it has been decided to concentrate for the present on the stable fuzzy-seeded strains.

On the other hand, the purer strain D28 has shown an improved yield, giving an 80 per cent increase over the previous season. The shedding percentage is much lower than the other strains as may be seen from Table I above. Field trials with this strain will therefore be continued in the 1931/32 season, there being sufficient seed for approximately 5 acres. After that season, if the improvement is maintained, it should be possible to test out the strain in the district among selected farmers.

PART II.

SELECTION AND BREEDING.

A total of 47 selections were planted at a spacing of 4′ × 1′6″ and 150 plants per selection were grown where possible. Every plant in this block was selfed. The selections were composed as follows :—

(a) 30 special individuals from the strains T66, T57, D28, T75, and T68.

(b) 15 from field selections in 1929/30, many of which were hybrids, and 2 from the native variety Ganvelga.

Of the 30 in (a) eight were abandoned during the season, and Table II attached gives the analysis of the remaining 22. Of these 22, 12 are considered valuable material and Table III attached gives details of individuals selected for plant to row work for next season.

It will be seen that the strain T66/40 is outstanding among these, combining good yield and lint length with a fair ginning per centage. This strain continues to show the desired flowering curve also, which is further discussed in the following section.

Of the 17 selections under (b) above eight were abandoned and Table IV attached gives details of those individuals from the remainder which will be continued next season.

PART III

PHYSIOLOGY AND DISEASE.

The routine flowering counts, shedding particulars and harvesting figures, as described in previous reports, were taken. An unusual season was experienced, a peculiarity being the delay in the onset of the *harmattan*. This is well demonstrated in the accompanying Atmometer Graph I. The noteworthy features of this are first, that no strong *harmattan* was experienced until early February, whereas in a normal season it may be expected about December, and secondly, the excessive day-to-day variations in humidity.

Rainfall during the cotton season (July-February) was 30 inches, 16 of which fell during August and September. This may be regarded as normal, though the rainfall of 0.89″ in December is rather higher than the expectation.

The flowering curves of the bulk of the strain D28 and of T66 selections are given in Graphs II and III. The first peak of D28 is undesirably early, and contrasts with that of T66, especially T66/40, an outstanding selection which approaches most nearly to the desired type, as did the parent strain (Graph V, Paper XXXVI, Year-Book 1929). The shedding curve is remarkably low in strain D28 for the period September to November, vide Graph II.

Tables V and VI below give the total incidence of disease and insect attack in shed bolls for the bulk strains, and the monthly incidence for the strain D28.

TABLE V.

PERCENTAGE INCIDENCE OF DISEASE AND INSECT ATTACK IN SHED BOLLS, 1930-31 SEASON.

Strain	Stainer	Bollworm	Physiological	Other Injuries	Mummied Bolls	Percentage of half-developed bolls shed.
D28 ...	13.4	21.2	20.4	24.0	21.0	9.6
T66 Smooth	13.0	22.8	20.7	28.7	14.8	10.6
T66 Fuzzy	12.4	24.4	22.6	25.9	14.7	12.7
T57 Smooth	15.2	22.4	23.8	25.1	13.7	13.4
T57 Fuzzy	15.1	22.7	22.5	25.4	14.3	12.4

LIVINGSTONE ATMOMETER READINGS
(White bulb exposed to the sun)

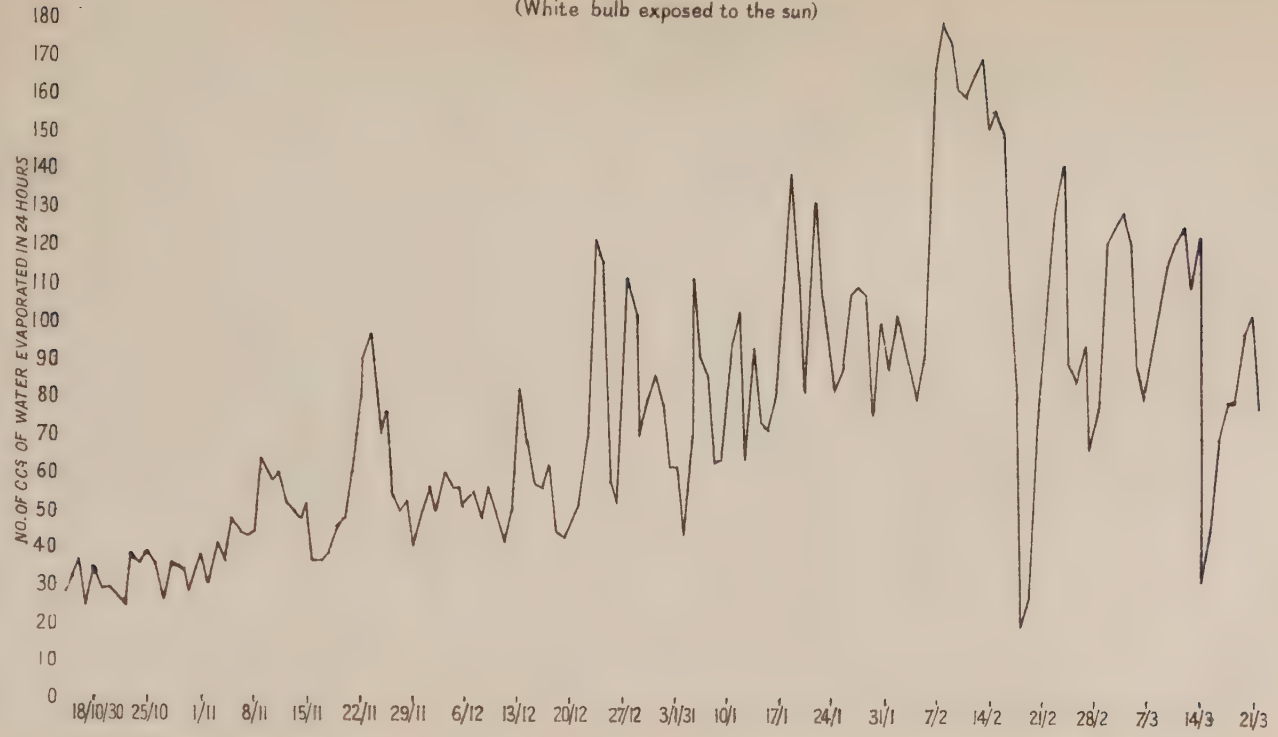


TABLE VI.

Monthly percentage Incidence of Disease and Insect Attack. Strain D28.

Month	No. of sheds per acre.	Stainer	Bollworm	Physiological.	Other Injuries	Mummied Bolls.	Percentage half-developed bolls shed.
Sep.	80	—	30.0	70.0	—	—	—
Oct.	13048	19.5	31.4	25.9	23.2	—	10.3
Nov.	14560	20.3	25.6	19.8	28.3	5.9	11.4
Dec.	24136	12.0	21.4	13.0	28.1	27.1	12.0
Jan.	24784	7.8	16.5	23.6	21.2	27.1	7.8
Feb.	7696	3.5	11.4	24.0	13.4	46.3	3.5

In comparison with the previous season there has been a slight increase in stainer attack and a decrease in shedding of half-developed bolls. It will be observed from Table VI that the incidence of stainer and boll-worm attack decreases steadily with the advent of drier conditions.

Tables VII and VIII below give the total lock analysis of the bulk strains and the monthly analysis of strain D28.

TABLE VII.

Lock Analysis of Harvested Bolls.

Strain.	No. of Bolls per acre.	Percentage of				
		Useless Bolls	Bolls with two or less locks developed.	Bolls slightly damaged or stained.	Clean Bolls.	Bolls showing bollworm injury.
D28	46,960	9	28	31	32	54
T66 Smooth ...	19,616	9	29	30	32	58
T66 Fuzzy ...	18,928	6	21	26	47	41
T57 Smooth ...	26,696	13	30	24	33	55
T57 Fuzzy ...	27,844	16	33	22	29	51

TABLE VIII.

MONTHLY LOCK ANALYSIS OF HARVESTED BOLLS. D28.

Month.	No. of Bolls per acre.	Percentage of				
		Useless Bolls	Bolls with two or less locks develo-ped.	Bolls slightly damaged or stained.	Clean Bolls.	Bolls showing boll-worm injury.
November ...	6,328	16	38	23	23	64
December ...	12,456	10	32	28	30	61
January ...	12,392	8	29	37	26	53
February ...	12,672	6	20	29	45	43
March	3,112	6	16	39	39	51

In comparison with the previous year there is a decrease in useless bolls and a corresponding increase in clean bolls. Boll-worm percentage remained constant. The monthly incidence shows clearly the increasing proportion of good bolls as the season became drier. Owing to difficulty in obtaining chemicals in time, this measure of boll-worm control could not be attempted during the season under review, but it will be seen from the following Table IX that approximately 40 per cent of all bolls produced were attacked by this pest.

TABLE IX.

PERCENTAGE OF BOLLS (SHED AND HARVESTED) ATTACKED BY BOLLWORM.

Strain	D28	T66S	T66F	T57S	T57F
Percentage attacked...	41.9	37.0	35.8	37.6	37.7

PART IV.

OTHER VARIETIES TRIED.

The following varieties were tried in Observation Plots during the season :—

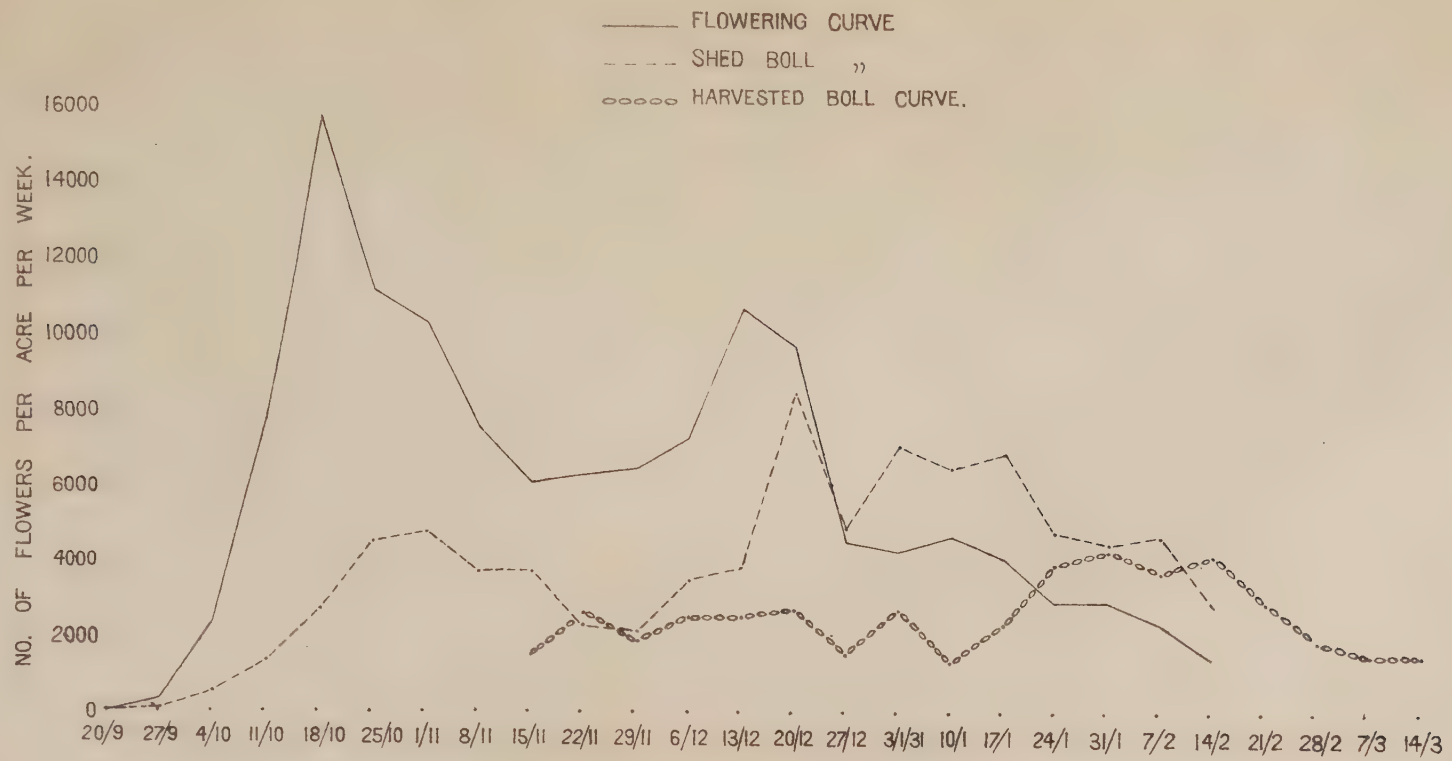
American : Zululand Hybrid, Improved Bancroft, Watts Long Staple, D. and P.L. No. 6, 4128A–21–32 (from D and P.L.), Delfos 911, Express 121, Webber, Nyasaland, and two from the Turkestan Plant Breeding Station.

Native : Sonko (from Kpeve District), Kpalgunda, and Ganvelga.

Asiatic : Coconadas 171, Nandyal, Karungani C7, and 6 strains from the Turkestan Plant Breeding Station.

GRAPH 2.

FLOWERING, SHED BOLL AND HARVESTED BOLL CURVES, STRAIN D 28.



SURVEY H.Q. ACCRA, 1931.

None of the above varieties showed any promise except two strains of the Asiatics, Coconadas and Karungani. Both of these gave a mean yield of 30.5 grammes per plant, though as was to be expected the lint length was short (13/16ths). A small yield trial will be carried out between them and selections have been made for plant to row work.

TRIALS WITH ARTIFICIAL MANURES.

The artificials used in this trial were Lime, Basic slag and Kainit. The rates of application were as follows :—

Lime 6 cwts. per acre, Basic slag 8 cwts., Kainit 2 cwts. These fertilizers were tried singly and in combination against controls untreated. Allen cotton was used. The layout was on the randomized block system, with 1/16th acre plots four times repeated. Planting distance 4′ × 1′. Planting date 9th July.

The results are appended in the following Table X :—

TABLE X.

Treatment.	Calculated Mean Yield per acre. lbs. seed cotton.
Control (no treatment)	30
Basic slag	41
Kainit	27
Lime	31
Basic slag and Kainit	48
Basic slag and Lime	36
Kainit and Lime	37
Basic slag, Kainit and Lime	47

The only block available for this experiment had light sandy soil. The yields obtained were very low, but are similar to those always obtained with Allen cotton before selection work commenced.

On statistical analysis the results proved that no single artificial showed significant differences over control or any other treatment, though Basic slag alone was almost significantly better than Kainit alone. Six significant differences between mean yields of treatments emerged. Basic slag and Kainit, and Basic slag and Kainit and Lime, were better than Lime alone, Kainit alone, and Control. It is considered, however, that the full effect of the artificial manures was not demonstrated on account of deficiency of organic material in the soil. In the same season Allen cotton planted elsewhere following a turned-in crop of Bengal beans gave a mean yield of over 300 lbs. seed cotton per acre. The cost of fertilizers delivered in Tamale is very high and quite uneconomic.

PART VI.

COTTON IN ROTATION TRIAL.

Allen cotton grown as part of a five-course rotation, commenced in 1929–30, and following a crop of Bengal bean turned in the previous season, gave yields varying from 250 lbs. seed cotton per acre to 420 lbs., with a mean yield of 328 lbs. This compares with a mean yield in the previous season of 157 lbs., when cotton was taken as the first crop after clearing. The beneficial effect of the green-manure crop is obvious.

SUMMARY.

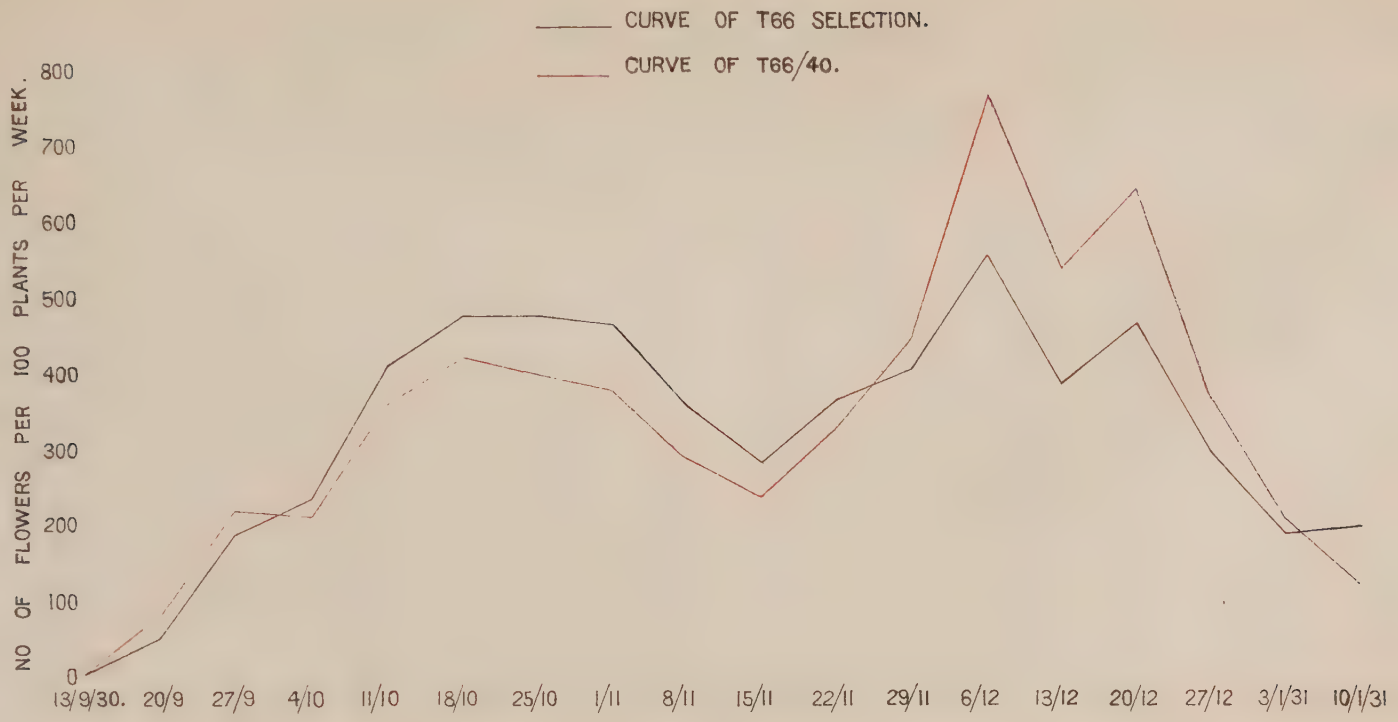
1. One strain, D28, has maintained its promise and given an increased yield. Further purification of the other two strains T66 and T57, is necessary before bulk trials can usefully be attempted.
2. Of new varieties tried, only two Asiatics, Coconadas and Karungani, showed any promise. It is hardly to be expected that the low prices usual for these types would give an economic return.
3. Boll-worm has again proved to be the major insect pest.
4. Trials with artificial manures shew that the effect generally is increase in yield. Basic slag was undoubtedly the most effective manure, but the greatest benefit was obtained when it was used in conjunction with Kainit. Lime alone and Kainit alone had no observed effect. The indication is that, without treatment to improve the organic content of the soil, artificials alone are of little use
5. The beneficial effect of a previous green-manure crop is clearly shown in the rotation experiment.

RECOMMENDATIONS.

It is recommended for the coming season that attention be concentrated on the strain D28. There is now sufficient seed for satisfactory field trials, and if yield is maintained it could be tested in the district the following season. Further purification and improvement should be carried out on the most promising selections of this and other strains.

GRAPH 3.

FLOWERING CURVES, STRAIN T66.



SURVEY H.Q. ACCRA, 1931.

TABLE II.

Yield Characteristics of Strains of T66, T57, T75 and D28.

No. of Strain.	No. of Plants before Rogueing.	Percentage Rogued.	Percentage Yielding.					Yield in grammes.	Total No. of Bolls.	No. of Bolls per plant.	Yield per plant.	Average weight per Boll.
			No Yield.	1–10 grammes.	10–25 grammes.	25–50 grammes.	Over 50 grammes.					
T66/40 ...	118	13.6	—	12.0	39.0	39.0	10.0	2823.5	1,208	11.8	27.7	2.7
T66/56 ...	136	31.6	2.3	23.6	37.6	23.6	12.9	2212.3	1,145	12.3	23.8	2.3
T66/57 ...	117	46.1	36.6	34.8	27.0	27.0	4.8	1040.7	639	10.1	16.5	1.9
T66/59 ...	123	30.9	1.1	22.4	44.8	28.3	3.5	1834.7	869	10.2	21.6	2.3
T66/126 ...	86	31.4	3.8	18.2	39.0	32.3	6.7	1426.1	604	10.3	24.2	2.6
T66/131 ...	90	42.3	—	23.1	30.8	34.6	11.5	1488.2	762	14.7	28.6	2.3
T66/133 ...	89	19.2	1.4	11.1	40.3	40.3	6.8	1785.9	761	10.6	24.4	2.8
T66/141 ...	156	26.3	5.3	30.4	40.8	18.2	5.3	2202.8	793	8.4	19.2	2.5
T66/144 ...	100	14.0	28.0	17.5	29.1	22.1	3.4	1312.0	645	7.5	15.3	2.5
T66/149 ...	123	17.8	1.9	41.6	45.5	9.9	1.0	1512.9	850	8.4	15.1	2.2
T57/49 ...	71	33.9	2.1	44.7	44.7	8.5	—	606.5	311	6.6	12.7	2.5
T57/50 ...	100	30.0	—	30.0	51.5	18.5	—	1114.3	579	8.2	15.9	2.3
T57/73 ...	111	23.4	2.4	25.9	47.2	21.2	3.5	1663.9	994	11.7	19.5	1.9
T57/118 ...	116	11.2	1.0	25.2	52.5	19.3	1.9	1919.2	894	8.7	18.6	2.5
T57/122 ...	103	6.8	—	21.9	56.0	18.8	3.3	1921.8	865	9.0	20.2	2.9
T57/140 ...	58	19.0	—	34.1	42.5	21.3	2.1	799.6	343	7.3	17.1	2.8
T75/70 ...	66	55.0	—	13.4	70.0	16.6	—	547.4	285	9.5	18.2	2.2
T75/174 ...	30	50.0	—	26.6	54.0	13.3	6.0	263.0	142	9.4	17.5	2.1
T75/175 ...	72	34.8	—	12.3	56.0	29.3	1.0	1026.0	485	10.3	21.7	2.5
D28/23 ...	68	5.9	1.6	43.7	51.6	3.1	—	686.4	449	7.0	10.8	1.8
D28/66 ...	85	18.8	—	59.5	37.6	2.9	—	700.9	449	6.8	10.2	1.9
D28/77 ...	31	22.6	—	25.0	54.6	20.4	—	452.5	254	10.6	18.8	2.2

TABLE III.

CHARACTERISTICS OF PLANTS TO BE GROWN PLANT TO ROW IN 1931–32 SEASON.

Plant No.	Weight of Seed-Cotton in grammes.	Lint Length (Combing)	Ginning Percentage.	No. of Bolls.	Mean Weight per Boll.	Type of Seed.
T66/40/28	52.1	14.5	30.6	17	4.3	Fuzzy
T66/40/35	66.3	16.1	30.4	26	2.7	Fuzzy
T66/40/61	42.8	14.4	34.2	16	3.3	Fuzzy
T66/40/68	60.5	15.0	29.5	26	2.7	Fuzzy
T66/40/71	22.2	18.3	29.0	12	2.2	Fuzzy
T66/40/72	48.7	14.2	30.0	17	3.0	Fuzzy
T66/40/77	85.0	15.1	29.2	37	2.7	Fuzzy
T66/56/42	68.9	14.2	33.5	32	2.4	Semi-Fuzzy
T66/126/24	73.8	14.8	27.5	33	2.5	Fuzzy
T66/126/47	49.2	15.0	30.5	15	3.8	Fuzzy
T66/126/49	103.2	14.1	26.6	41	2.7	Fuzzy
T66/131/52	65.2	14.8	26.0	24	3.2	Fuzzy
T66/131/53	120.4	13.7	26.8	45	3.1	Fuzzy
T66/131/56	109.0	41.1	28.4	35	3.6	Fuzzy
T66/141/68	106.2	15.0	—	34	3.5	Fuzzy
T66/141/93	40.4	15.5	—	14	3.4	Fuzzy
T57/122/42	68.1	16.1	29.4	25	3.3	Semi-Fuzzy
T57/122/67	39.4	14.9	32.0	19	2.8	Fuzzy
T57/73/39	79.3	14.0	33.2	38	2.4	Fuzzy
T57/73/53	78.0	14.4	30.8	31	2.7	Fuzzy
T57/118/41	69.0	15.0	31.0	33	2,4	Fuzzy
T57/118/72	103.7	15.0	28.4	41	2.9	Fuzzy
D28/77/8	49.9	15.2	31.1	24	2.5	Fuzzy
D28/77/15	40.3	15.2	30.1	18	2.8	Fuzzy
D28/23/68	41.2	15.6	28.6	19	2.4	Fuzzy
T75/174/4	56.5	14.8	33.0	26	2.4	Fuzzy
T75/175/17	26.6	17.1	33.3	10	3.0	Fuzzy
T75/175/42	52.8	15.3	32.8	32	1.8	Fuzzy
T75/175/44	44.9	16.1	28.6	16	3.2	Fuzzy
T75/175/46	41.8	16.1	33.0	22	2.2	Fuzzy.

TABLE IV.

CHARACTERISTICS OF PLANTS SELECTED IN 1930–31 SEASON AND TO BE GROWN IN 1931–32 SEASON.

Plant No.	Weight of Seed-Cotton in ounces.	Lint Length (Combing)	Ginning Percentage.	No. of Bolls.	Mean Weight per Boll.	Type of Seed.
S19/1 ...	25.1	16.6	26.3	28	1.0	Smooth
S17/8 ...	41.1	15.3	32.7	24	1.9	Fuzzy
S17/85 ...	91.4	14.5	35.2	34	2.9	Fuzzy
S25/4 ...	70.3	18.7	33.3	34	2.3	Fuzzy
S25/1 ...	32.8	15.4	32.0	18	1.8	Smooth
S31/20 ...	29.9	13.9	31.0	16	2.1	Smooth
S33/1 ...	44.5	16.0	33.0	28	1.8	Smooth
S35/35 ...	42.0	14.6	32.0	16	2.8	Fuzzy
S35/2 ...	71.4	14.2	30.8	20	4.1	Fuzzy
S41/4 ...	43.0	15.1	32.9	15	3.1	Fuzzy
S41/28 ...	44.5	15.3	33.7	20	2.5	Fuzzy
S44/38 ...	41.6	15.3	35.2	19	2.5	Smooth
Ganvelga 2	50.2	14.0	33.0	25	2.3	Fuzzy
Ganvelga 3	32.7	14.5	32.6	26	1.5	Fuzzy

PAPER No. XXI.

RESULTS AT ESIAMA RICE MILL.

By F. A. ROBB.

The history of the rice industry in Eastern Nzima, the steps taken by Government to stimulate production through the erection of a power-driven mill near Esiama, and the results obtained during its first two years of working were described in the 1928 Year-Book (Paper No. XXI).

In this article it is proposed to give an account of the rice industry for the three succeeding years, 1928–29 to 1930–31, and to show the results obtained at the mill during that period.*

I.—THE RICE INDUSTRY.

The annual production of paddy during the past five years is given below :—

	Season.				
	1926–27.	1927–28.	1928–29.	1929–30.	1930–31.
Production of paddy in tons	35.28	128.42	191.20	106.25	289.21

Centres of Rice Production.

The map opposite page 180 shows the centres from which paddy was brought to the mill during 1930–31 and should be contrasted with Plate XLVIII opposite page 158 in the 1928 Year Book. It will be noticed that an increasing number of villages are growing rice ; but until recently, development has been greatest in the area near to the mill.

In Appendix I a list is given showing the amount of paddy that each village has sent to the mill during each of the past five years.

Apart from the year 1929–30 there has been a steady increase in production. This increase, though not as rapid as was at one time expected, may be regarded as promising, and there is no doubt that the industry is becoming firmly established in the district. In all probability future development will be more rapid.

*Throughout this article the year taken is the Financial Year (April to March inclusive). There is a slight overlap of crops in successive years but not sufficient to alter the figures materially.

In the establishment and development of any new agricultural industry, numerous obstacles and difficulties have to be met and overcome. These difficulties are being gradually overcome.

In common with farmers the world over, the African farmer is conservative, in other words he wants to be well assured that a proposed new crop will be remunerative to him. Once he is assured on this point, especially by seeing his fellow farmer benefit and make money from a crop, he will plant extensively. Indications of a growing interest in the industry are not lacking in the district.

Suggested Stimuli to Future Development.

It was stated above that early development was chiefly in an area within easy reach of the Rice Mill. The close contact with the mill, few transport difficulties, and the influence of the Ohene of Esiama—Nana Kofi Ampoe II—in continually advocating the growing of rice and in personally farming a large tract of land, are some of the factors responsible for this development.

The construction of a feeder road leading from the Bongere River to Esiama has brought within economic distance of the mill an extensive area of land. It is necessary, however, that the numerous watercourses in this area should be made navigable. Unfortunately, though urged by their own people to do so, the Amanhene concerned have not taken any interest in this work nor, so far, attempted in any way to make these streams navigable.

The development of the industry in parts of the district (notably above Ebi Greek and Yiribuni) has been cramped and impeded by the levying of excessive tolls on canoes passing along these waterways. In the general interest of the industry these tolls should either be made nominal or removed altogether.

It is well known that in most countries rice farming demands a greater expenditure of energy than almost any other agricultural crop. This is undoubtedly true of the local industry, and if improved methods of farming that would have the effect of economising labour could be introduced, they would certainly result in more people growing rice and in larger areas being cultivated.

The obvious solution is the employment of mechanical implements, but at the present stage of development this is impracticable. Farmers have not the capital nor have they the knowledge to understand the use of such implements. Later on, through agricultural co-operative societies, it may be possible to do something in this direction. The implements would be owned communally and let out on hire under the charge of a trained man.

The improvements suggested at the present time are—

(*a*) the planting of two successive crops on the same land ;

(*b*) the use of sickles or of specially made knives, whereby several stalks of paddy can be cut together. The local practice is to cut the stalks one by one and the harvesting of the crop is not only slow but there is a considerable loss of grain by shedding ;

(*c*) the introduction of small hand-threshing machines, either owned individually or co-operatively.

The improvement of rice seed is receiving attention and it is hoped that within the next two years seeds of selected high-yielding strains will be available for distribution.

Marketing of Farmers' Rice.

The centralised system of selling the rice from the mill direct to the merchant has continued satisfactorily during the period under review.

Although the price of rice has been affected by the prevailing depression in trade, the local industry has not suffered to the same extent as some other agricultural industries. The rice produced at Esiama is all sold within the Colony. Its price is, naturally, governed by that of imported rice. While rice can be produced more cheaply in Asiatic countries than at Esiama, the cost of freight has to be added to its production cost. The locally grown rice does not suffer from this drawback. Further, in so far as towns inland are concerned, the locally produced rice enjoys the benefit of a lower rate of transport on the railway than imported rice.

During 1930-31, farmers were receiving slightly more for their rice than the cost of imported rice. This concession which was made by the firm purchasing the rice, will encourage it is hoped, the development of the industry, and, at the same time, increase the commercial possibilities of the district.

II.—THE RICE MILL.

The efficiency of the Rice Mill has been improved by the removal of the two dust cyclones to an out-building, the installation of a mechanical winnower and the erection of a paddy store.

Milling Records.

Details of the monthly milling records are given in Appendix II.

Rice returned to Farmers and Rice retained by Mill.

For financial reasons it was considered advisable in 1928 to reduce the amount of milled rice returned to the farmers from 58 lbs. to 56 lbs. per 100 lbs. of paddy. The distribution of the rice is given in the following table :—

Year.	Total Rice.		Returned to Farmers.	Retained by Mill.	
	Tons.		Tons.	Tons.	
	Whole.	Broken.		Whole.	Broken.
1928–29	123.57	5.89	107.20	16.37	5.89
1929–30	68.91	4.08	59.36	9.55	4.08
1930–31	180.46	7.98	154.01	26.45	7.98

Financial Aspect of the Rice Mill.

The capital cost of the Rice Mill at the end of the financial year 1925–26 was £3,256 0s. 7d. and the annual capital charge allowed £499 16s. 6d.*

In 1929–30 a paddy store was erected and a mechanical winnower installed at a cost of £313 16s. 11d. and £78 11s. respectively. This increased the capital charge by £56 18s.

FINANCIAL YEAR, 1928–29.

Revenue.	£	s.	d.	*Expenditure.*	£	s.	d.
Sales 1927–28 rice	133	4	0	Milling costs ...	123	17	7
Sales 1928–29 rice	324	2	10	Spares	108	16	7
Net Loss	475	3	10	Interest on capital, etc.,	499	16	6
	£932	10	8		£932	10	8

Revenue.	£	s.	d.	*Expenditure.*	£	s.	d.
Sales	294	11	4	Milling costs ...	231	4	4
Net Loss	530	9	6	Spares	37	2	0
				Interest on capital, etc.,	556	14	6
	£825	0	10		£825	0	10

FINANCIAL YEAR 1930-31.

Revenue.	£	s.	d.	*Expenditure.*	£	s.	d.
Sales	430	17	0	Milling costs ...	277	17	5
Net Loss	438	4	11	Spares	35	0	0
				Interest on Capital, etc.,	556	14	6
	£869	11	11		£869	11	11

The above statements are satisfactory in so far as the revenue has more than covered working expenses and the provision of spares.

Analyses of milling costs.

Analyses of the milling costs for the three years are shown below:—

*In Paper XXI. 1928 Year-Book, the annual capital charge was shown as £515 11s. 10d. Insurance was charged on capital expenditure instead of plant and buildings only.

FINANCIAL YEAR 1928–29.

Milling costs ... £323 17 7 Total paddy milled 191.2 tons.

Head of Expenditure	*Amount.*	*Expenditure per ton of paddy milled.*
	£ s. d.	£
Labour	219 14 11	1.15
Kerosene ...	63 2 8	.33
Grease and waste	1 7 2	.01
Freight and transport ...	8 0 3	.04
Miscellaneous ...	31 12 7	.16
	£323 17 7	£1.69

FINANCIAL YEAR 1929–30.

Milling costs ... £231 4 4 Total paddy milled 106.25 tons

Head of Expenditure.	*Amount.*	*Expenditure per ton of paddy milled.*
	£ s. d.	£
Labour	172 1 3	1.62
Kerosene ...	18 11 11	.18
Grease and waste	1 16 0	.02
Freight and transport ...	9 15 5	.09
Miscellaneous ...	28 19 9	.27
	23 4 4	2.18

FINANCIAL YEAR 1930–31.

Milling costs £277 17s. 5d. Total paddy milled 278.47 ton

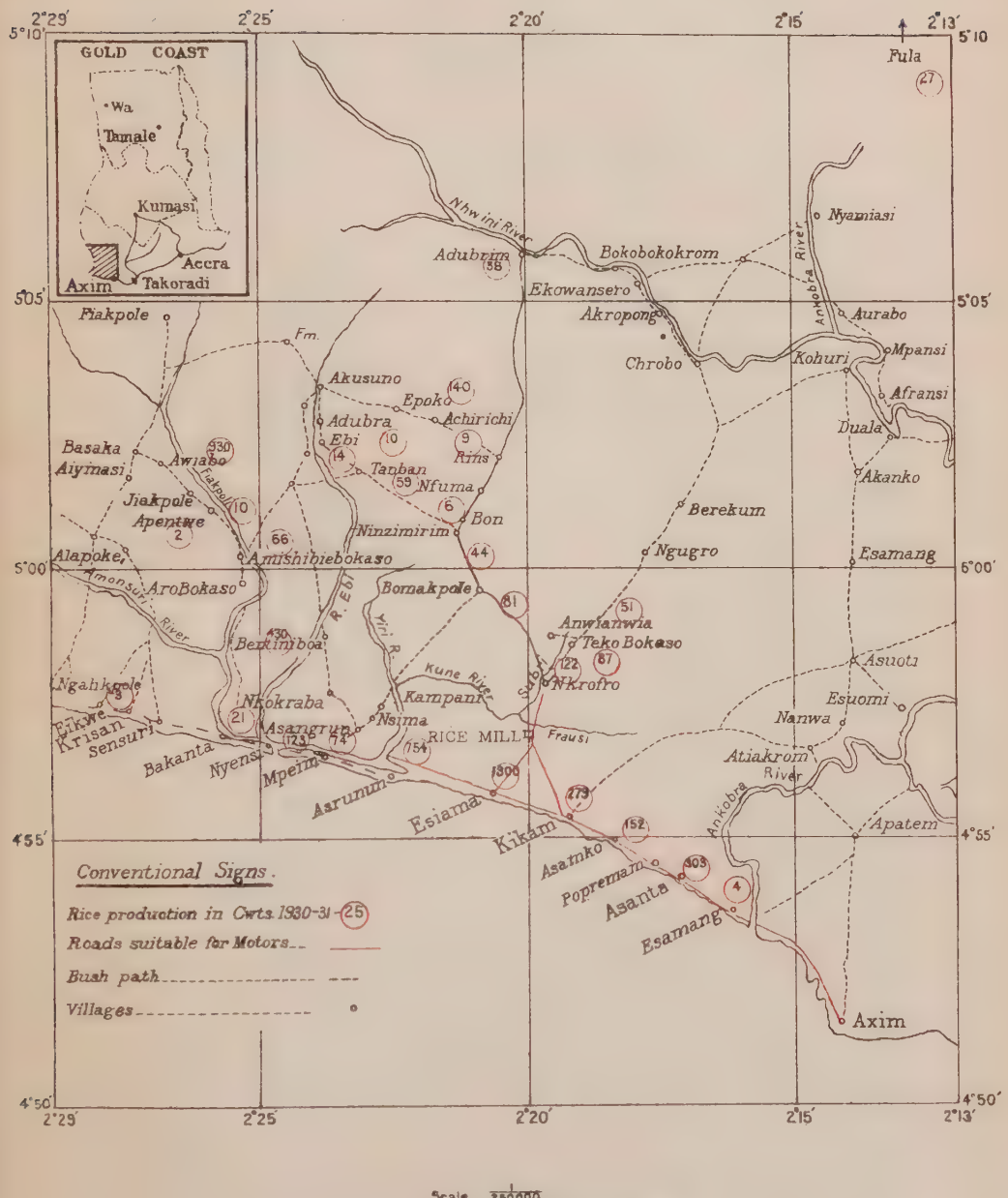
Head of Expenditure	*Amount.*	*Expenditure per ton of paddy milled.*
	£ s. d.	£
Labour	191 9 6	.687
Kerosene	61 5 0	.219
Grease and waste	1 6 0	.005
Freight and transport	4 11 10	.016
Miscellaneous	19 5 1	.069
	£277 17 5	£0.996

APPENDIX I.

List showing Paddy received from villages.

Name of Village.	1926–27.	1927–28.	1928–29.	1929–30.	1930–31.
	lbs.	lbs.	lbs.	lbs.	lbs.
Adubrim ...	—	3,418	—	—	4,296
Adubra ...	—	—	—	—	1,074
Achirichi ...	—	—	—	—	952
Akropong ...	—	—	—	176	—
Amishidiebokaso	—	—	—	—	7,397
Ancobra ...	665	4,535	7,090	1,950	416
Anorchi ...	—	—	—	1,590	—
Anwianwia ...	333	2,655	2,452	—	5,696
Asangrun ...	3,670	23,415	30,329	15,398	13,797
Asamko ...	258	3,621	11,602	8,111	17,305
Asanta ...	24,803	38,701	60,949	13,552	33,884
Asrunun ...	—	50,406	88,952	41,418	84,437
Awiabo ...	—	—	1,479	2,978	104,170
Bakanta ...	—	—	—	3,388	2,348
Bansu ...	—	—	—	3,515	—
Bentiniboa ...	—	6,731	19,719	13,658	48,181
Berekum ...	—	325	—	—	—
Bobroema ...	130	—	1,280	—	—
Bomakpole ...	—	—	—	140	9,104
Bon	—	—	—	734	721
Brofo	616	—	—	—	—
Dixcove ...	—	—	—	1,078	—
Ebi	—	—	—	—	1,602
Eikwe ...	—	—	—	—	35
Epoko... ...	—	—	—	2,154	15,632
Esiama ...	22,440	87,931	106,113	38,380	145,609
Esowa... ...	—	—	1,130	—	—
Fula	—	—	—	4,437	3,064
Investigational Station ...	—	—	—	—	5,423
Jiakpole ...	—	—	—	—	1,154
Kikam ...	17,291	52,788	71,563	47,655	31,449
Kokofri ...	—	—	2,258	4,396	—
Komuasi ...	90	—	—	—	—
Kpendew ...	—	—	—	—	264
Kutokrom ...	—	—	—	2,254	—
Mpeim ...	5,322	5,051	3,910	1,253	8,254
Ninzimirim ...	—	—	—	—	4,802
Nkrofro ...	3,248	5,890	3,754	22,834	80,822
Nsima ...	—	80	—	—	—
Salama ...	—	—	—	428	—
Sensuri ...	116	—	—	—	—
Suawua ...	—	—	—	1,013	—
Tanban ...	—	—	—	1,716	6,668
Tekobokaso ...	—	2,122	15,790	3,795	9,704
Total ...	78,972	287,669	428,370	238,001	647,930
	35.28 tons	128.42 tons	191.2 tons	106.25 tons	289.21 tons

ESIAMA RICE MILL AREA.



SURVEY H.Q. ACCRA, 1931.

APPENDIX II.

Financial Year, 1928–29.

Month.	Paddy.	Winnowing.		Milling.					Percentage Rice to Paddy.	No. of Hours Milling.		Output per Hour.
		Clean Paddy.	Percentage Loss.	Polished Rice.	Broken Rice.	Dust, etc. from Husk Aspirator Shaker.	Meal and Bran from Huller and Polisher.	Husks (obtained by difference).				
	lbs.	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.		H.	M.	lbs.
April	27,956	27,268	2.4	18,450	998	571	2,217	5,032	71.4	50	5	386
May	33,657	33,220	1.3	22,292	1,375	908	2,451	6,194	71.2	30	15	782
October ...	66,798	65,839	1.55	43,552	2,305	1,715	6,550	11,717	69.66	77	—	583
November ...	28,370	28,001	1.3	18,652	1,035	737	2,918	4,659	70.31	30	25	647
December ...	65,683	64,842	1.29	42,853	2,390	1,647	7,509	10,443	69.76	64	55	697
January	144,668	128,067	5.5	85,739	4,695	3,462	13,248	20,923	70.60	116	50	774
February		8,739		5,625	321	277	969	1,547	68.05	8	45	680
March	61,238	59,480	2.95	39,643	2,336	2,061	6,267	9,173	70.57	64	40	650
Total ...	428,370	415,456	2.94	276,806	15,455	11,378	42,129	69,688	70.36	442	55	660
Percentage to Paddy ...	—	—	—	66.64	3.72	2.74	10.14	16.78	—	—		—

Financial Year, 1929–30.

Month.	Paddy.	Winnowing.		Milling.					Percentage Rice to Paddy.	No. of Hours Milling.		Output per Hour.
		Clean Paddy.	Percentage Loss.	Polished Rice.	Broken Rice.	Dust, etc. from Husk Aspirator Shaker.	Meal and Bran from Huller and Polisher.	Husks (obtained by difference).				
	lbs.	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.		H.	M.	lbs.
April	5,109	4,998	1.9	3,314	198	155	516	815	70.26	6	40	526.5
May	13,102	12,897	1.6	8,740	418	424	1,137	2,178	70.99	15	40	584.5
September ...	1,744	1,726	1.03	833	175	157	304	257	58.39	5	20	189
October ...	55,554	55,097	0.8	35,666	2,625	2,387	7,415	7,004	69.47	73	35	520.5
November ...	59,753	58,584	1.9	38,671	2,646	1,912	8,437	6,918	70.53	71	10	580.5
December ...	27,652	27,285	1.3	18,491	1,000	846	3,476	3,472	71.42	29	10	668
January ...	24,489	24,204	1.16*	15,136	780	854	3,240	4,194	65.80	25	15	626
February ...	22,354	22,033	1.43*	15,076	558	602	2,192	3,605	70.96	24	50	629.5
March	28,244	27,831	1.4*	18,446	750	789	2,624	5,222	69.00	27	10	706
Total ...	238,001	234,655	—	154,373	9,150	8,126	29,341	33,665	69.68	278	50	586.5
Percentage to Paddy ...	—	—	—	65.79	3.9	3.46	12.5	14.34	—	—		—

*Loss in storage. Mechanical winnower installed in January.

Financial Year, 1930–31.

Month.	Paddy.	Percentage Loss in storage.	Milling.					Percentage Rice to Paddy.	No. of Hours Milling.		Output per Hour.
			Polished Rice.	Broken Rice.	Dust, etc. from Husk Aspirator Shaker.	Meal and Bran from Huller and Polisher.	Husks (obtained by difference.)				
	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.		H.	M.	lbs.
April	3,800	0.5	2,479	88	84	402	737	67.74	5	—	513
October	76,342		48,905	2,623	2,353	9,406	13,055	67.51	88	35	584
November	102,436		67,209	3,307	3,346	11,436	17,138	68.87	121	—	574.5
December	8,444		5,412	324	345	1,032	1,331	67.95	10	40	576
January	56,498	0.9	36,134	1,088	1,732	6,353	11,191	65.88	59	50	622
February	141,672		92,314	3,828	3,871	15,211	26,448	67.85	158	50	607
March	234,590		151,768	6,622	6,813	21,999	47,388	67.53	265	10	597
Total	623,782	—	404,221	17,880	18,544	65,839	117,288	67.66	709	5	596
Percentage to Paddy ...	—	—	64.79	2.87	2.97	10.55	18.8	—	—		—

PAPER No. XXII.

ROOT ROT OF COCO-YAMS.

By J. Wright.

INTRODUCTION.

Root diseases of *Xanthosoma* spp. and *Colocasia* spp. have been recorded in Jamaica, Porto Rico, Egypt, San Dominigo and Hawaii.

A root disease of " Cocoes " (*X. sagittifolium*) in Jamaica, was attributed by Ashby (1) in 1912 to a vascular fungal pathogen, which he named *Vasculomyces xanthosomae*. This fungus was found in the least affected tissues and was thought to provide a means of entrance for other fungi, especially a species of *Fusarium*, bacteria and animals, which together brought about the conspicuous aspect of the disease, the description of which corresponds closely to the disease of coco-yams in the Gold Coast.

In Porto Rico a root disease of " yautias " (*Xanthosoma* sp. and *Colocasia* sp.) was first reported by Barrett in 1905 (2) and later by Stevenson (20) in 1927. According to these workers the disease was probably due to a vascular parasite but they were unable to isolate any pathogenic organism. This disease, which is known as " el mal " is stated to be favoured by poor soil and dry weather. Another root disease, " carrutaca," causing serious damage to crops, was described by Diaz and Buso (11) in 1925. The symptoms appear to be the same as in " el mal," but this disease exists only in wet localities. It is stated that if the fecula is cut, black threads are found which denote the presence of the causal organism. Then in 1926, Cook (10) reported that two types of root rot of " yautias " occur in Porto Rico, one caused by a bacterium, the other by *Sclerotium rolfsii*.

In Egypt, Briton-Jones (3) found a species of *Rhizoctonia* attacking and causing severe damage to *Colocasia* plants.

In 1927, Ciferri (9), working in San Dominigo reported that he had isolated *Bacillus caratovorus* from the rotted rhizomes of *X. sagittifolium* and showed that several members of the *Araceae* were among the most susceptible hosts of the organism.

It is interesting to note that Hartig (13) found that aroids in storage are subject to four distinct rots. These are a " black rot " caused by *Diplodia* spp., a " powdery grey rot " by *Fusarium solani*, a " sclerotium rot " by *Sclerotium rolfsii* and a " soft rot " by *Bacillus caratovorus*. All these organisms are wound parasites.

According to Carpenter (4–7) the predominant organism in diseased " taros " in Hawaii is a fungus which resembles *Pythium debaryanum*. Infection experiments with this fungus, though not numerous, gave positive results. He found that pythiaceous fungi also caused root disease in sugar cane (Lahaina disease), pine-apple, rice and banana but he was of the opinion that soil conditions were an important if not a determining factor in the occurrence of the disease. His description of the histology of diseased roots applies to what has been observed in coco-yams by the writer. He found that the strain isolated from taro differed from the others in that it produced conidia. In a later paper (8) the sugar cane organism is referred to as *Pythium aphanidermatum*.

How long cocoyam root rot has existed in the Gold Coast is uncertain but it is now in many districts a very serious affection of this staple crop. It was first recorded by H. A. Dade who found the late stages of the disease at Wankye, near Oda in 1925. In 1926 he found that the disease was prevalent in the neighbourhood of Anyinam. No early stages were found and the material available for examination was in an advanced state of decay. In the absence of other demonstrable organisms capable of causing rot, Dade suspected that nematodes were the probable cause.

In December, 1929, the writer found the early stages of the disease in several places on the south side and along the top of the Kwahu scarp and it was also very prevalent along the valley of the River Birim in the district round Anyinam ; about the same time J. C. Muir, found the disease in the neighbourhood of Dunkwa. Recently the same disease has been found in the neighbourhood of Kibi.

The distribution of the disease at present would appear to be the valleys of the rivers Birim, Pra, Anum and Offin within that area which is roughly included by the Dampia Range, Kwahu hills and Kibi hills. It is probable that the disease occurs elsewhere though not to such a serious extent.

Material was collected from several sources for examination. Several organisms were found associated with the rot but these could not be successfully traced in the tissues, nor were infection experiments successful. Only a few sections were found to contain hyphae and the total evidence of fungal infection was very scanty. Nematodes were found in large numbers but only, however, in the rotted tissues. A few dissections showed the elements of the conductive tissue packed with masses of motile, rod-shaped bacteria. These were traced in the tissues up to half an inch in advance of the discoloration.

The early stages of the disease were found again in September in material planted by the writer. From observation on this material the symptoms, course of the disease and the histology of many of the affected roots correspond with the observations of Carpenter (loc. cit.) on diseased taros in Hawaii.

VISIBLE SYMPTOMS OF THE DISEASE.

The disease may appear any time after planting. The sprouting "seed" pieces may never push a shoot above the soil; plants may make an extremely stunted growth and plants may die off after having become well established.

Plants have been found which were only one foot to 18 inches high eight months after planting. This slow development is accompanied by the production of abnormally small leaves.

In well established plants the visible symptoms of the disease are a flaccid appearance and yellowing of the leaves. Chlorotic patches appear and often the leaf becomes attacked by the leaf spotting fungi *Cladosporium colocasiae* and *Phyllosticta colocasiae* and by woolly aphids and scale insects. Wilting of the whole plant ensues. (Plate 1.)

The roots, on examination, exhibit a dying back, accompanied by a blackening, necrosis and wet rot. This usually starts from the tips but often from lesions which may occur anywhere in the length of the root. Complete discoloration and death of the roots is rapid. At those points on the corms where the roots arise, rotted hollows are formed and gradually complete putrefaction takes place. The decaying corms are usually coated with the typical mycelial felt of *Sclerotium rolfsii*.

PATHOLOGICAL HISTOLOGY.

Tender tissues appear to form starting points for the disease: such are root tips and young rootlets.

Microscopic examination of the tissues of diseased roots, adjacent to the discoloured areas, reveals the presence in the cortical and phloem parenchyma of abnormal quantities of granular tanniferous bodies, sometimes fused in masses, gums, raphide sacs and sphaeroraphides of calcium oxalate. No hyphae were found in this or in the less discoloured of the advancing diseased area, which would suggest that the development of the causal organism is accompanied by the formation of an enzyme.

In the more discoloured regions of many of the roots where the tissues still retain turgidity, coenocytic, granular hyphae ramifying through and between the cells of the cortex are predominant.

These hyphae have been observed in all tissues except the xylem. Some hyphae have been traced into root hairs. Occasionally rounded spore bodies have been found in this region. (Plate 2, Fig. 1).

As the tissues lose turgidity the phycomycetous mycelium appears to become more profuse, irregularly swollen and globular. and the hyphae coiled into nests.

PLATE I.

Healthy and badly diseased cocoyam, three months old; var. AMANKANI FUFU. (X8½).

Plate 2.

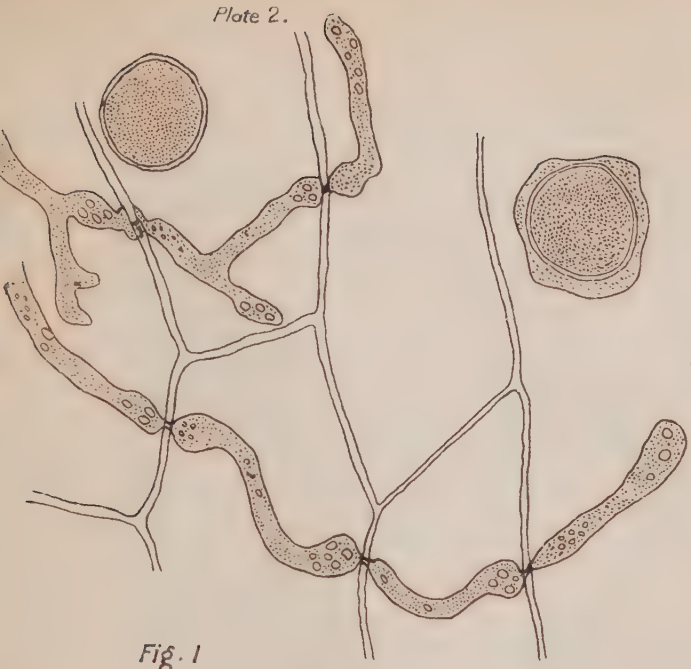


Fig. 1

DESCRIPTION OF PLATE.2

Fig. 1. Longitudinal hand section of discoloured but turgid part of diseased root showing stout granular hyphae and two 'spore bodies' of the pythiaceous fungus. (camera lucida)

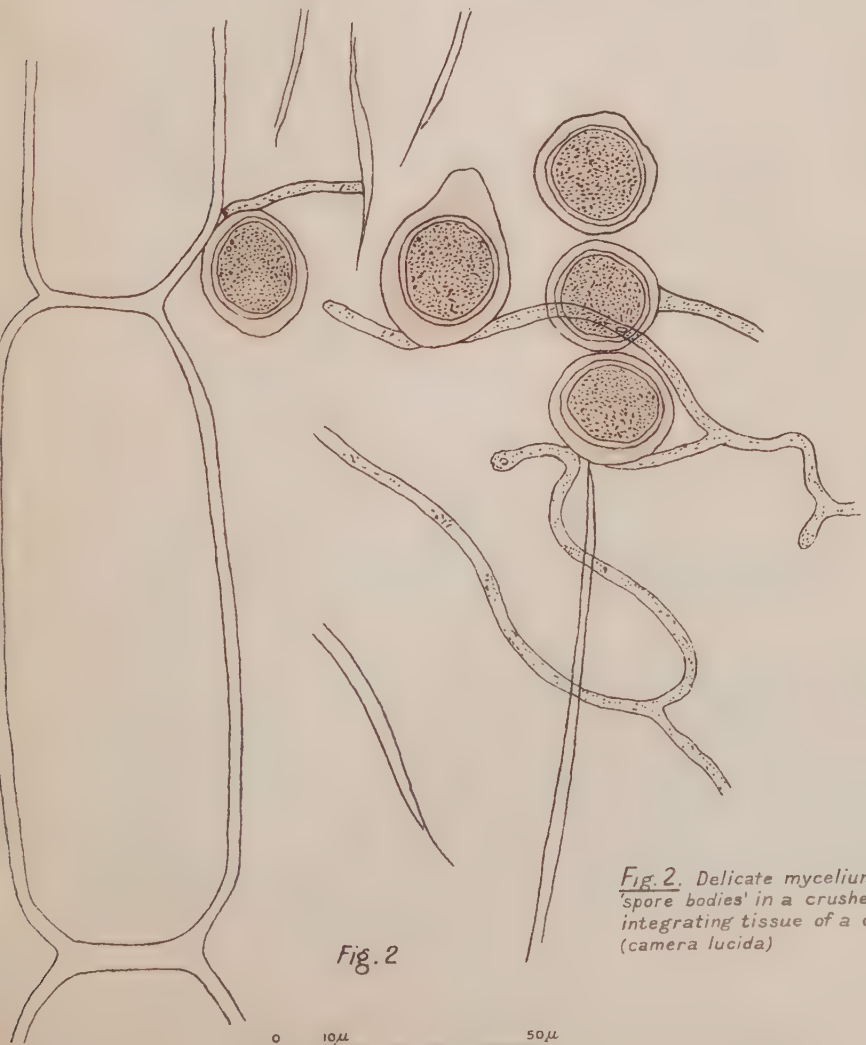


Fig. 2

Fig. 2. Delicate mycelium and collection of 'spore bodies' in a crushed piece of the disintegrating tissue of a diseased root. (camera lucida)

SURVEY H.Q. ACCRA. 1931.

On crushing the disintegrating tissues the rounded spore bodies are found to be much more common. Coenocytic hyphae are seldom found and the few which have been observed in this region are delicate and hyaline. (Plate 2, Fig. 2.).

To quote Carpenter (loc. cit.), whose observations on the disease in Hawaii appear to agree with the writer in this country . . . . "while some of the rounded spore bodies appear to be conidia (sporangia) and resting conidia, the majority are thought to be oospores within the remnants of the oogonium. The thick-walled spores generally are not found in the young lesions but abundantly in the softened tissues, and the mycelium which has preceded the spores is generally not visible, though if searched for, traces of it are occasionally seen attached to the vestiges of the oogonium-like wall surrounding the oospore."

Numerous nematodes, rotifers, mites, bacteria and the hyphae of several fungi are always found in the rotted tissues.

ORGANISMS ASSOCIATED WITH THE DISEASE.

At first, isolations were attempted from the cortical tissues in advance of the discoloured zone, and from the junction of the discoloured and fresh tissues. All attempts met with failure. Microscopic examination, carried out later, revealed the reason for this as the absence of organisms from these regions.

Isolation from the discoloured but turgid tissues yielded the following micro-organisms :—

Fusarium spp.
Rhizoctonia sp.
Actinomyces spp.
Yeasts.
Bacteria.

One species of *Fusarium* was of very common occurrence but none of the organisms was invariably present.

Sclerotium rolfsii was present on most old diseased material but it has often been found on fresh corms in areas where there is no disease.

Up to the present the phycomycete which is prevalent in diseased tissues has not been isolated. It is possible that the first methods adopted were unsuitable. The usual methods of surface sterilisation by means of mercuric chloride, alcohol and flaming may be too severe for this fungus. This was suspected and washing thoroughly in running sterile water and then transferring pieces of the tissues to solid or liquid media which had been acidified to pH 4.5 to eliminate bacteria was adopted. This again proved unsuccessful. Recent work by Flor (12), however, on the very

similar fungus attacking sugar cane, *Pythium aphanidermatum*, has shown that the maximum acidity which the fungus can tolerate is pH 4.6 and that the initial optimum hydrogen ion concentration for its development is pH 8.5.

Accordingly, the reaction of several kinds of media has been varied but without success.

Pieces of fresh coco-yam roots have been sterilised and inoculated with a piece of diseased material containing the phycomycete and several days later the pieces of roots have been transferred to various media but this, too, has been unsuccessful.

Attempts to isolate this fungus are being continued.

INFECTION EXPERIMENTS.

(A) Initial experiments were tried by washing some of the roots of healthy plants, grown in boxes, free from soil and inoculating them with the various organisms isolated. The disturbance of the roots, however, was sufficient in many cases to cause them to die off and the results obtained were valueless.

(B) Corms were placed in moist chambers and produced roots. Roots were inoculated at the tips with the various organisms. After a few days these as well as the uninoculated roots all started to die back from the tips.

(C) Corms were potted up in sand in which was incorporated the contents of tubes containing cultures on corn-meal agar of the organisms to be tested. The sterile medium was used in the control pots. Four of the most commonly occurring organisms were tested, three pots inoculated with each thus :—

3 pots *Fusarium* sp. A.
3 pots *Fusarium* sp. B.
3 pots *Rhizoctonia* sp.
3 pots *Bacillus* sp.
3 pots Control.

The plants were watered twice a day with Sachs' nutrient medium.

The plants developed well and when the experiment was terminated after seven months all the plants were quite healthy.

(D) Four boxes were filled with soil. Diseased material, chopped up into small pieces, was incorporated with the soil in two of the boxes, and a similar quantity of chopped fresh material was added to the other two boxes, to serve as control. Four corms were planted in each box and watering was done once per day. The

plants became well-established and after eight months, when this experiment was terminated, all were healthy. Further, the chopped pieces of both diseased and fresh material, which had contained buds, had produced small plants.

Several times since this last experiment corms and pieces of corms of plants which have been dying off from the disease have been placed in pots and tins of Aburi soil together with the trash of the diseased plants and in most cases the plants arising from these "seed pieces" have been quite healthy. In a few odd cases where the decaying corms of plants which had been very severely attacked by the disease were used, only weakly shoots were produced and these soon died off. In such instances, however, no roots were formed and they cannot therefore be considered as reproductions of the diseased condition.

The indications which may be derived are :—

(1) That infection does not take place in the conditions under which the plants were grown at Aburi. The condition of the soil would appear to be the determining factor.

(2) That infection does not occur from "seed."

(3) That the products of disintegration of old plants do not affect the development of new plants.

These experiments would suggest that the disease, presumably caused by a strain *Pythium aphanidermatum*, which is normally a soil saprophyte, can only occur when the plant is subjected to some physiological disturbance, which did not exist in the condition under which the plants were grown at Aburi.

Observation on the conditions of growth in those areas where the disease occurs were therefore conducted.

WATER RELATIONSHIP.

Root disease of *Xanthosoma* spp. and *Colocasia* spp., in other countries, have usually been found to be associated with wet conditions. One exception is the "el mal" disease in Porto Rico, which is stated to be associated with poor soil and dry conditions.

Preliminary observations in the Gold Coast would suggest that wet conditions are conducive to the disease.

In Kwahu the disease is worst in those areas where cacao is suffering badly from "black pod" disease, where there is obviously a wet, heavy soil and a high relative humidity.

Around Anyinam where the disease is so prevalent, the soil has high clay and silt fractions and very little sand, and, that it suffers from waterlogging, is indicated by the presence of much

stagnant water during the wet season. On the slopes above the village of Moseaso, near Anyinam, coco-yams may be cultivated successfully and here the soil is very gravelly and it appears to be well drained.

On the Atewa Range above the villages of Afease and Afwenease, which are near Kibi, steep slopes seem to support good coco-yams while in the wetter low-lying areas the production of coco-yams is nearly impossible.

These observations would lead to the conclusion that bad drainage is a possible factor in the incidence of the disease. There are, however two outstanding objections. One is that the coco-yam is a water-loving plant, the other that soil which will not support coco-yams yields good crops of maize and plantains.

To test the effect of drainage on the incidence of the disease a field experiment was carried out in the vicinity of Anyinam on an area adjacent to some food farms where the cultivation of coco-yams is impossible.

The secondary bush which was cleared for the lay-out of the experiment was about three years old, and it was found that part had previously been used for cassava cultivation. An area 117 feet by 72 feet was pegged out and divided up into 40 plots, each 12 feet square, separated by paths, three feet wide.

"Hilling up" was adopted as the easiest method of draining. Every alternate plot was broken up into four mounds, each about two feet high from the bottom of the drain.

The "seed pieces" were obtained from a disease-free patch near Anyinam. 400 plants were raised on the flat in the normal manner and 400 on the mounds, five to each mound.

Planting operations were carried out on 6th May, 1930, and a careful record was kept of the appearance of the disease. It was recorded first of all on 4th June, on the mounds where infection was slightly more rapid than on the flat as is shown by the accompanying table which indicates the incidence of the disease at the end of each month.

The experiment was terminated on 10th December, when all the 800 plants had the disease and many of them were dead. Only 67 plants, 36 on the flat and 31 on the mounds, produced cormels and these were very small.

The experiment shows that drainage has no beneficial action and that it may even hasten the incidence of the disease.

Month.	Mounds.		Flat.	
	Number freshly diseased.	Total diseased.	Number freshly diseased.	Total diseased.
June	3	3	—	—
July	7	10	4	4
August	36	46	19	23
September	99	146	86	109
October	85	230	32	161
November	126	356	113	274
December	44	400	126	400

A short experiment on the effect of waterlogging on the development of the coco-yam was conducted at Aburi.

Twelve kerosene tins, six of which were punctured, were filled with soil, and a coco-yam corm planted in each. The soil was kept sufficiently moist to ensure the development of the plants. After the leaves had appeared the water supply was altered as follows. Of the six punctured tins, four were watered twice a day and two once a day but the plants in the latter two tins were covered with bell-jars. The six unpunctured tins were treated in a similar fashion, until the water level rose to the surface of the soil and thereafter water was only added occasionally to maintain this level.

After seven weeks the leaves of the plants under the bell-jars had become so contorted that it was necessary to terminate that part of the experiment. The root systems of these four plants were quite healthy.

The remaining part of the experiment was terminated after six months. All plants developed equally for about five months and at this stage the plants in the drained tins began to show signs of wilting. At the end of the sixth month the effect was as shown in the photograph (Plate 3).

The root systems of the wilted plants, however, were quite normal.

The latter part of this experiment was repeated and a similar result was obtained.

The health of the plants, therefore, appears to be injured by drainage. This result was unexpected but it supports the conclusion arrived at in the above field experiment—that drainage has no controlling action but, by adversely affecting the health of the plants, hastens the appearance of the disease.

SOIL REACTION AND SOLUBLE TOXINS IN THE SOIL SOLUTION.

Several workers have attributed root rot in some plants to the presence of soluble aluminium salts in acid soils. McGeorge (18) found nodal accumulations of iron and aluminium salts in diseased sugar cane and Hoffer and Carr (14) observed a similar phenomenon in diseased maize plants. In a study at the Royal Hungarian Institute of Plant Physiology on root rot of sugar beet data were obtained which showed that an increase in the aluminium content of the tissues preceded invasion by *Pythium debaryanum*, *Phoma betae* and *Aphanomyces levis*.

McGeorge (17) found that in Hawaii, soils with an acidity of pH 5.8. and lower, contained salts of manganese, iron and aluminium. Less acid soils did not contain these salts.

The reaction of the soil in those areas where the cocoyam disease occurs have been tested and none have been found acid enough to permit of the presence of these soluble toxins. In nearly all cases the reaction is nearly neutral, varying from pH 6.5 to pH 7.5. No differences in reaction have been found in good and in bad cocoyam soils, other than the differences which exist in the two cases.

NUTRIENTS PRESENT IN THE SOIL SOLUTION.

To function normally, plants which are manufacturing and storing large quantities of carbohydrate reserves, require large amounts of available potash. Roots and storage organs are much richer than other organs in potash content.

It has been shown by a Japanese worker, Hori, whose paper is abstracted by Hulsemann (15), that *Colocasia antiquorum*, for its optimum development, requires about five times as much potash as phosphoric acid. " Dry speck " disease of this plant, caused by *Cladosporium colocasiae*, which involves wilting of the foliage and death of the roots, was promoted by the excessive use of nitrogenous and phosphatic manures.

In Hawaii, Carpenter (8) found that excess of nitrogenous nutrients and the products of cane trash decomposition in the soil predispose Lahaina sugar cane to root rot, while Martin (16) found that stimulative nitrogenous materials added to the soil in which Lahaina cane had previously been grown free from disease, created an environment in which root rot became serious.

Recently, Sears (19) has shown that a relationship exists between the availability of potash and the quantity of nitrate nitrogen present in the soil.

Hori (loc. cit.) was able to cure *Amorphophallus konjac*, a plant belonging to the same order as the cocoyam, of a pathological condition by the protracted application of wood ash over a period of five to six years.

PLATE III.

Effect of water on the development of cocoyams in kerosene tins—plants seven months old. The four tins to the left are undrained, the four to the right are drained.

Results of work with these diseases would indicate that a potash deficiency is probably a primary factor in the occurrence of the diseases and certain observations on coco-yam disease in this country point to a similar deficiency as the cause.

The following points are of interest in this connection :—

(*a*) Farmers maintain that the disease does not occur on virgin soil.

(*b*) Coco-yams may develop normally for two or three years in a farm which has been cleared from secondary bush and then their cultivation gradually becomes impossible.

(*c*) It has been observed that coco-yams grown in soil from which the secondary bush had been burned off—and to which potash has thus been supplied—develop much better than those in areas where clearing only has been carried out. These plants may eventually succumb to the disease but the farmer is usually able to reap a few cormels.

(*d*) In the field experiment on drainage only three plants developed to reasonable dimensions. These were growing on the edge of a plot near which a large heap of bush cuttings had been fired when the plants were about two months old. The plants had been attacked early by the disease but had made a good partial recovery.

(*e*) While clearing the bush for the drainage experiment it was found, as stated previously, that part of the area had been used about three years before for the cultivation of cassava. The effect which this had on disease incidence was most striking. The appearance of the disease was general throughout the plot but, initially, severe attack was confined to this cassava area, the distribution being quite diagrammatic. Within six months all the plants on this area were dead or dying and at the termination of the experiment they were all dead as distinct from most of the other diseased plants on the plot which were still producing weakly shoots.

It may be presumed that the cassava would have removed large quantities of available potash and the severity of the disease within the cassava area would support the view that a potash deficiency is responsible for the trouble.

Miss Field, Achimota, kindly consented to carry out some analyses in connection with this potash deficiency problem but owing to her leaving the country the work had to be abandoned soon after its commencement.

The following were the only figures obtained. Soil from near Kibi where the bush had been burned off four or five months previously had a potash content (reckoned as percentage of fine earth) of:—

.09 per cent at a depth of four inches.
.08 per cent at a depth of one foot.

Soil from the diseased area near Anyinam, where the bush only was cleared had a potash content of .03 per cent.

The following analyses might prove interesting:—

(1) Analyses of good and of bad coco-yam soils as regards content of potash and nitrogen as nitrate.

(2) Determination of the potash content of the central corms of healthy and of diseased coco-yam plants.

Field experiments ought to be carried out on the effect on the incidence of the disease of—

(*a*) protracted applications of wood ash,
(*b*) applications of potassic fertilisers.

VARIETAL SUSCEPTIBILITY.

Ashby (loc. cit.) found that in Jamaica a difference in susceptibility to attack by root rot existed between the various varieties of "cocoes.' A variety—'Sally'—was rarely attacked even in very badly diseased areas.

In the Gold Coast five different types of coco-yams are grown.* The writer was informed by several farmers that a difference in susceptibility to disease existed between these: *Amankani Pa* and *Amankani Fufu*, the popular varieties were most susceptible; the Appolonian varieties, *Amankani Fita* and *Amankani Antwibo*, were slightly more resistant but were very scarce, while the disease had never been known to attack *Koko*, the indigenous *Colocasia antiquorum*.

A test was made with four local varieties at Anyinam on a site adjacent to the plot which was used for the drainage experiment. The figures obtained, shown in the accompanying table indicate that all four are very susceptible to the disease. *Amankani Fufu* may have slightly more resistance than the other varieties but the test is not adequate to state that this variety is definitely more resistant.

Variety.	Age of plants.	Number planted.	Number healthy.	Number attacked by disease.	Number dead.
Amankani Pa ...	9 months	100	3	97	58
Amankani Fufu ...	7 months	100	49	51	31
Amankani Antwibo	6 months	30	1	29	23
Koko	8 months	100	1	99	31

* *Vide*—Paper XXIII—Coco-yams in the Gold Coast.

In 1927, H. A. Dade introduced the white Trinidad "dasheen" into the Anyinam District for trial on soil which would not support the local varieties. No plant became established, all succumbing to the disease early in development.

DISCUSSION.

From the strong similarity of the symptoms and course of the disease it seems quite probable that root rot of coco-yams in the Gold Coast is the same disease as is recorded for *Xanthosoma* spp. and *Colocasia* spp. in various parts of the world.

The disease is attributed in the different countries to definite organisms, viz., *Vasculomyces xanthosomae* associated with a species of *Fusarium*, *Sclerotium rolfsii*, *Rhizoctonia* sp., *Bacillus caratovorus*, *Cladosporium colocasiae* and *Pythium aphanidermatum*. Of these Hartig (loc. cit.) has shown that at least *S. rolfsii* and *B. caratovorus* are able to attack tubers in storage but that they are wound parasites. Several of the organisms are included among those which have been found associated with the disease in this country but none have been found to be invariably present in diseased tissues.

The role played by the species of *Pythium* in disease attack is interesting and it is most unfortunate that this fungus has resisted all attempts at isolation. It would appear, however, that this fungus is the same *Pythium aphanidermatum* which was isolated from diseased "taros" in Hawaii by Carpenter (loc. cit.) and shown to be pathogenic, though the experiments were not numerous. From attempts to induce infection at Aburi, using roots containing the fungus as inoculum, it is obvious that some condition of the host or environment is necessary for fungal penetration. Observations on diseased roots suggest that the *Pythium* in the tissues is of a very transient nature, which might be due to some autolytic action, but this fungus appears to be responsible for opening up the way for attack on the moribund tissues by the various organisms found associated with diseased roots.

The writer is of the opinion that all the organisms, including this species of *Pythium*, are soil saprophytes and only become capable of attacking the roots when the plant is in a debilitated state and the roots have already begun to die off. The most probable reason for this condition in those areas in the Gold Coast where the disease occurs is a soil deficiency in available potash

CONTROL.

Until such a time when scientific agriculture is practised in the Gold Coast the following measures of control, based on observations on the disease are suggested :—

1. Where it is still possible, coco-yam farms should be made on virgin soil or on soil which has not previously been used for root crops.

2. The bush should be burned off and not only cut down and cleared away. The coco-yams should be liberally manured with all available wood ash.

3. The site of the farm should be cleared sufficiently to eliminate as much as possible root competition and dense shade. Weeding should be carried out a little oftener than is generally the case. In other words, the health of the plants should be given a little more consideration. Coco-yams appear to like plenty of moisture and at the same time plenty of light.

4. The present practice of carrying on a farm until the soil is more or less exhausted should be modified. The period in many cases, with the sacrifice of a little more work, could be considerably reduced. Even reaping two or three generations of coco-yams from the same plot must remove large quantities of available soil nutrients.

5. Two practices which ought to be abandoned are—

   (*a*) The custom of planting the "seed' in exactly the same soil from which the previous generation has just been removed.

   (*b*) The use, generation after generation, of the same old stump as "seed." This practice is bound to lead to degeneration.

SUMMARY.

1. A description of a disease of coco-yams in the Gold Coast is given.

2. The disease takes the form of a root rot, wilting of the leaves and inability to form tubers, followed in severe cases, by death and putrefaction of the entire plant.

3. Several organisms have been found associated with the disease but none is invariably present in diseased tissues. The only fungus which appears to be of any importance in the determination of disease is a species of *Pythium*, probably *Pythium aphanidermatum*.

4. This fungus is of a very transient nature in diseased tissues but it occurs in advance of the other organisms.

5. Moisture conditions and soil reaction do not affect the incidence of the disease.

6. All varieties are susceptible.

7. From observations, the writer is of the opinion that the disease is mainly physiological and that the cause is a soil deficiency in available potash.

8. Suggestions for future work on the potash deficiency problem are made.

9. Possible control measures, based on observations in the field are enumerated.

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PAPER No. XXIII.

COCO-YAM VARIETIES IN THE GOLD COAST.

By J. WRIGHT.

INTRODUCTION.

Certain members of the natural order *Araceae* are cultivated in tropical countries for their starchy rhizomes, which yield a valuable food. The plants occur under numerous names in the different countries and even in the same country, and wherever they are grown a number of varieties are distinguished. In Hawaii, where the 'taro' is cultivated extensively, over 200 varieties are recognised.

In the Gold Coast the plants are now known as 'coco-yams' a term applied in the West Indies. Five different types exist of which four are varieties of *Xanthosoma sagittifolium*, Schott, and a variety of *Colocasia antiquorum*, Schott.

No trace of the introduction of the latter variety into these parts can be obtained and it seems probable that this plant is indigenous to West Africa. The *Xanthosoma* varieties form a comparatively recent importation. They were brought from the West Indies by West Indian missionaries who landed at Accra on 17th April, 1843. Other food plants introduced at this time were Oranges, Mangoes, Sweet sop, Avocado, Breadnut, Bread-fruit, Arrowroot and Coffee. The coco-yams were planted at Akropong—Akwapim during June and since then they have gradually spread all through the forest belt. Their starchy cormels form the staple food of the Twi speaking peoples and have now become a popular article of diet in Trans-Volta and of some of the coast peoples.

CULTIVATION OF COCO-YAMS.

That coco-yams have been planted almost everywhere where virgin forest has been cleared for farming is indicated by the procedure adopted at the present day to form a coco-yam farm.

A piece of secondary bush, anything up to an acre in extent, is cut down and burned off or cleared away. This is usually done towards the end of the *harmattan*. On the advent of the rains and without any more work on the part of the farmer, coco-yams spring up all over the cleared area. They arise from plants which, prior to clearing, had been leading an incipient life or from old pieces of

Fig. 1. Subterranean system of an NTEWFORO plant of an AMANKANI PA variety showing central corm and radially arranged flask-shaped cormels. (¼ Nat. size).

Fig. 2. Subterranean system of second generation plant showing rhizome and oval shape of the tubers of the ADANKASA. (¼ Nat. size).

tubers which for years had been lying dormant in the soil. How long such tubers remain viable is unknown but the following example illustrates that it is probably a considerable period. Part of the *Funtumia* plot in the Aburi Botanic Gardens was cleared away when the trees were 34 years old. Within a month of clearing, coco-yams sprang up all over the cleared area. Presumably, coco-yams had been growing on the area when the *Funtumia* trees were planted, but due to weeding, shade, root competition or other factors they had apparently died out. Over this long period of years, however, some tubers had remained dormant in the soil and had retained their viability. On the necessary conditions for growth being resumed these tubers had produced healthy plants. These plants which spring up in cleared soil are termed *Odokoto* by the Twi farmer.

Where the plants are growing too thickly they are thinned out and in the gaps pieces of ' seed,' consisting of portions containing buds of old rhizomes from old coco-yam farms, are planted in holes made with a cutlass or hoe so that the plants will be spaced roughly 3 feet $\times$ 3 feet. All the plants in the farm are now termed *Ntewforo*.

Where intercropping is practised the *Odokoto* may only be thinned out and maize, plantains, yams, onions, beans, etc., planted in the gaps.

As an *Ntewforo* plant develops, a large corm is formed on the ' seed ' at the base of the petioles. The cormels usually the only part of the plant which is used as food, arise in a radial manner on this central corm. The number of cormels produced varies considerably but eight to ten is an average quantity. They are approximately flask-shaped and usually from six to nine inches in length. (Fig. I).

The plant reaches maturity in a year to 18 months. Ripeness of the cormels is indicated by the yellowing of the leaves of the plant. If the crop is left too long the cormels may begin to sprout and become watery. Before the plants are mature it is a common practice to remove the largest of the cormels near the surface of the soil and thus induce the plants to produce fresh cormels. At maturity the plant is dug up with a cutlass and the cormels removed. The leaves are then cut away, the central corm trimmed down and the remaining stump is pushed into the soil from which the crop has just been reaped or simply thrown down and roughly covered with soil to serve as ' seed ' for the next generation. The type of plant arising from this ' seed ' is quite different in its underground system from the *Ntewforo* plant. No central corm is formed. The old stump increases in size to a rough, gnarled rhizome which produces roots and tubers on its lower parts. These tubers are smaller than the cormels of the last generation and vary in shape from round to oval. (Fig. 2). This crop is termed *Adankasa*. It is reaped in a similar manner and at the time of harvesting the old stump is again trimmed down to serve as ' seed.'

This process may go on for generation after generation of plants until such time when the yield and quality of the produce have deteriorated to such an extent that the farmer decides to give up the farm and allows it to become overgrown. After several generations the *Adankasa* tubers, when they are boiled lose that toughness which is necessary for the preparation of *fufu* and become hard and brittle. This is usually the standard of quality.

The farmer always has several farms of different ages, the number and the number of years which he cultivates each one depending on the area of land which he owns. The area is also the limiting factor of the length of the period during which the farm is allowed to become bush. The period is very seldom less than six years and the other limit is uncertain: it may be anything from 30 to 50 years.

COCO-YAMS AND CACAO.

The rapid spread of the coco-yams through the forest belt of the Gold Coast is without doubt associated with the planting up of cacao. The coco-yam is an admirable temporary shade plant in young cacao plantations and provides a good catch crop. Dwarfed coco-yams will be found in almost every cacao farm, the progeny of the original shade plants which have resisted harvesting, weeding, cultivation and other disturbing factors. It would appear that their small size is due in no small measure to shade for when some large shade tree comes down, as is a common occurrence, or several cacao trees die out and cause exposure, the coco-yams develop to their normal dimensions.

VARIETIES.

A. Varieties of *Xanthosoma sagittifolium.*

(1) *Amankani Pa or Amankani Kokoo.*

Large plant, 6–8 feet high. Leaf sagittate, dark green, lighter on the under surface, prominent venation; petiole reddish-purple. Tubers pink. Plant flowers in the wetter districts.

This is the common variety and is said to possess all the desirable properties of cooking, texture and taste.

(2) *Amankani Fufu.*

Very similar to *Amankani Pa.* Leaf not quite so dark; petiole pale purple. Tubers white.

(3) *Amankani Fita.*

Above-ground parts resemble *Amankani Fufu* but the plant is much more delicate. Tubers are white and the cormels have one or several constrictions. They are smaller than in the above two varieties.

(4) *Amankani Antwibo.*

Similar to *Amankani Fita*; petioles are very pale green and cormels pink and unconstricted. The central stem of this plant is edible.

Varieties (3) and (4) are known as Appolonian or *Wasa* varieties.

B. Variety of *Colocasia antiquorum.*

(1) *Koko.*

Plants usually 4–6 feet high. Leaf peltate, light green, smooth surface ; petiole pale green. Tubers white and smaller than in the *Amankani* varieties. The central stem of this plant is also edible.

At one time this was the favourite variety but now it is seldom eaten except in cases of scarcity and because of the softness of the food. by toothless old men and women. Because of its poisonous properties it has to be boiled for 12 hours before it is edible as compared with 20 minutes in the case of the other four varieties. The food is very soft and is unsuitable for *fufu.*

This paper is compiled from observations made during work on Coco-yam Root Rot ; from information supplied by farmers and by Messrs. J. J. Obeng and R. La of the Mycological Division of the Department. The historical information was obtained from the Rev. N. T. Clerk, Adawso, a son of one of the West Indian missionaries.

The photographs are by Mr. Obeng.

PAPER No. XXIV.

AGRICULTURAL PRODUCE CROSSING THE VOLTA RIVER AT SENCHI FERRY FOR THE PERIOD OCTOBER 1929 TO SEPTEMBER, 1930.

By C. L. SKIDMORE and H. B. DANIEL.

INTRODUCTION.

In Paper No. XVII* by A. C. Miles in the 1929 Year-Book, an account of the total quantities of produce crossing Senchi Ferry on the Volta River for the period October, 1928 to September, 1929, was given as well as reasons for the check and a discussion of the figures.

During the year October, 1929 to September, 1930, this recording has been continued and will be maintained.

STATISTICS.

Table I.

Table I sets out the quantities of principal agricultural produce recorded as passing from the Trans-Volta area over the Senchi Ferry from October, 1929 to September, 1930. The distribution of the amounts into the chief centres of origin and destination is also shown, and the Table has been given a comparative value by entering the quantities recorded for the previous period.

Inspection of the figures shows that the following produce has shown an increase: beans +74 per cent, cacao +28.71 per cent and *kokonte* (peeled split cassava tubers) +711.67 per cent whilst the following have declined in amount: coffee, coco-yams, groundnuts, tiger nuts, yams and water-yams.

The increase in the quantity of cacao is probably attributable to new areas coming into bearing and to the narrowing margin between the prices offered by the French and English buyers.

The decrease in the quantities of foodstuffs despatched to Accra coincided with the general fall in price of cacao and a consequent fall in price of farm foodstuffs. This placed the distant producer at a disadvantage and he suffered from competition from areas nearer to the big markets of Accra and Koforidua.

*"Agricultural Produce crossing Volta River at Senchi Ferry" by A. C. Miles.

In addition, swarms of locusts did considerable damage in 1929, before late maize was harvested in the Keta and Frankadua areas, whilst in March, 1930, corn areas in Togoland were heavily infested. This resulted both in a reduced balance of corn for sale and in an increased local consumption of other farm produce.

Locusts damaged the corn crop in the Akuse District and the large quantity of *kokonte* imported into that area must also have lessened the quantity of other foodstuffs available for export from Togoland.

Table II.

Table II records the quantities of agricultural produce checked as entering the Trans-Volta area. This check was instituted in April, 1930, and the period referred to in the Table is for the financial year April, 1930 to March, 1931. It has, consequently, no comparative value.

The cola trade, representing over half-a-million nuts, results from consumption in the northern areas and from the overland traffic to French territory.

The apparent anomaly created by the transportation of food crops in both directions across the Volta is explained mainly by the fact that certain farm-owners—especially in the Anum District—have their farms in the Akim and Birim areas. Foodstuffs grown by the farmers there are transported to the owners of the areas at Anum. Price differences probably account for the balance.

Trade Statistics.

In addition to the check on agricultural produce going up country, a record was also taken of the imports into the Trans-Volta area of trade goods such as cement, iron sheets, lime, soap, coal-tar, flour, rice and provisions of all kinds. These trade returns do not feature in this paper but will be of interest later in showing the trend and areas of development in the Trans-Volta and the part played by road traffic in an area that is not served by a railway.

TABLE I.

Agricultural Produce Crossing Senchi Ferry from the Trans-Volta Area.

(Quantities are shown in tons except where otherwise stated.)
(Period October to September).

Agricultural Produce.	Total Quantities. 1928–29.	1929–30.	Chief Centres of Origin, 1929–30.		Chief Destinations, 1929–30.	
Beans ...	18.1	31.5	Ho ...	23.66	Koforidua	14.32
			Palime ...	4.46	Accra ...	13.46
			Penyi ...	.35	Akuse ...	1.34
			Kpando ...	.19	Others ...	2.38
			Others ...	2.84		
Cacao ...	1703.1	2,192	Peki ...	644.06	Akuse ...	1038.47
			Chito ...	455.94	Accra ...	878.97
			Ho ...	273.62	Somanya ...	234.44
			Kpedze ...	199.28	Others ...	40.12
			Hohoe ...	89.16		
			Others ...	529.94		
Coffee ...	7.5	2.5	Logba ...	1.33	Accra ...	1.99
			Kpedze ...	.37	Somanya ...	.51
			Others ...	.80		
Corn ...	683.2	654.2	Frankadua	529.02	Accra ...	443.69
			Ho ...	29.34	Akuse ...	115.48
			Kpando ...	23.16	Kpong ...	22.57
			Sabuda ...	15.43	Others ...	72.46
			Others ...	57.25		
Capsicum spp.	1.6	11.0	Palime ...	3.23	Accra ...	7.05
			Ho ...	2.98	Koforidua	1.67
			Kpando ...	.44	Kpong ...	.61
			Others ...	4.35	Suhum ...	.52
					Others ...	1.15
Coco-yams ...	82.3	63.3	Kpedze ...	13.22	Akuse ...	27.49
			Kpando ...	7.48	Accra ...	21.54
			Peki ...	4.32	Kpong ...	5.99
			Chito ...	3.33	Koforidua	4.53
			Others ...	34.95	Others ...	3.75
Garri ...	74.7	192.5	Ho ...	99.91	Accra ...	84.04
			Palime ...	58.98	Akuse ...	8.36
			Kpando ...	17.27	Koforidua	3.38
			Others ...	16.34	Others ...	96.72
Groundnuts	175.1	123.3	Ho ...	93.55	Accra ...	101.15
			Palime ...	19.40	Koforidua	14.76
			Kpetoe ...	3.90	Akuse ...	2.89
			Others ...	6.45	Others ...	4.50
Kokonte ...	84.8	688.3	Kpando ...	218.91	Akuse ...	533.41
			Frankadua	71.51	Accra ...	65.32
			Ho ...	55.90	Kpong ...	42.01
			Golokwati	48.62	Koforidua	10.63
			Chito ...	23.84	Others ...	36.93
			Others ...	269.52	Accra ...	1.79
Oranges ...	32.0	3.3	Peki ...	.92	Koforidua	.40
			Kpando ...	.70	Kpong ...	.36
			Chito ...	.67	Others ...	.75
			Others ...	1.01	Accra ...	.75
Onions ...	1.1	1.6	Ho ...	.32	Nsawam ...	.21
			Keta ...	.18	Others ...	.64
			Others ...	1.10	Akuse ...	31.17

TABLE I—*continued.*

Agricultural Produce.	Total Quantities.		Chief Centres of Origin, 1929–30.		Chief Destinations, 1929–30.	
	1928–29.	1929–30.				
Palm Kernels	12	44	Kpedze ...	6.98	Accra ...	2.39
			Kpando ...	3.68	Somanya ...	.14
			Peki ...	1.21	Others ...	10.30
			Others ...	32.13	Accra ...	71.67
Palm Oil ...	52.3	101.6	Kpando ...	28.97	Koforidua	10.77
			Anfoe ...	21.41	Mangoase ...	5.81
			Aveme ...	9.88	Akuse ...	3.49
			Kpedze ...	7.76	Others ...	8.86
			Vakpo ...	3.56		
			Others ...	30.02	Accra ...	2.27
Plantains ...	5.7	6.0	Peki ...	1.16	Akuse ...	1.80
			Kpedze ...	.88	Kpong ...	.98
			Ho ...	.80	Larteh ...	.54
			Kpando ...	.33	Others ...	.41
			Others ...	2.83	Accra ...	6.41
Tiger nuts ...	11.5	7.4	Palime ...	5.82	Koforidua	.40
			Ho ...	1.58	Others ...	.59
					Accra ...	205.23
Yams ...	786.6	423.8	Kpando ...	110.32	Koforidua	79.33
			Ho ...	67.20	Larteh ...	32.31
			Palime ...	56.82	Akuse ...	15.40
			Veh ...	41.29	Somanya ...	6.08
			Aveme ...	30.95	Others ...	85.45
			Golokwati	23.02		
			Others ...	94.20	Akuse ...	1.15
Water-yams	4.9	2.5	Abuati ...	.57	Accra ...	1.07
			Chibu ...	.51	Others ...	.28
			Sabuda ...	.26		
			Others ...	1.16		
Calabashes	26,402	13,942	Ho ...	7206	Koforidua...	5504
			Chito ...	1420	Accra ...	5129
(Nos.)			Lome ...	1390	Akuse ...	888
			Nkwanta	1229	Kpong ...	680
			Palime ...	1034	Suhum ...	650
			Others ...	1663	Somanya ...	572
					Others ...	519
Cotton ...	—	2.3 tons.				
Silk Cotton	—	4.8 cwts.				
Mats... ...	—	21.7 cwts.				
Native soap	—	8.9 cwts.				
Sponges ...	—	9.0 cwts.				
Cattle (Nos.)	3,477	3,920	Bawku	750	Kpong ...	2,163
			Yendi ...	616	Somanya ...	15
			Pusiga ...	320	Koforidua ..	2
			Mongowi...	255	Others ...	1,740
			Zuarungu	108		
			Others	1,871		
Goats (Nos.)	11	73	Ho ...	41	Koforidua ...	25
			Yendi ...	12	Kpong ...	24
			Others ...	20	Others ...	24
Pigs (Nos.) ...	14	84	Dafo ...	10	Kpong ...	16
			Dekpo ...	9	Bisa ...	12
			Ho ...	9	Somanya ...	9
			Others ...	56	Others ...	47
Sheep (Nos.)	14,498	12,098	Bawku ...	1,815	Kpong ...	4,515
			Pusiga ...	759	Koforidua ...	1,057
			Yendi ...	707	Somanya ...	422
			Krachi ...	698	Accra ...	72
			Others ...	8,119	Others ...	6,032

TABLE II.

AGRICULTURAL PRODUCE ENTERING THE TRANS-VOLTA AREA.

(*Period April*, 1930—*March*, 1931.) (*Quantities are shown in tons.*)

Produce	Total Quantity.	Chief Centres of Origin.		Chief Destinations.	
Cola	10.36	Asamankese ...	4.95	Jasikan ...	3.33
		Koforidua ...	2.59	Kpando ...	1.49
		Accra	1.28	Palime... ...	1.38
		Bisa	1.22	Hohoe ...	1.29
		Kpong ...	.42	Sokoto... ...	1.18
		Others ...	.90	Others ...	2.69
Coco-yam ...	8.90	Suhum ...	5.35	Anum	7.19
		Nsawam ...	.76	Peki	.77
		Others ...	2.79	Others ...	.94
Corn	2.27	Koforidua ...	.86	Keta	.85
		Akuse	.70	Hohoe ...	.70
		Huhunya ...	.70	Anfoe	.56
		Others ...	.01	Others ...	.16
Onions ...	.57	Awunaga ...	.57	Abutia... ...	.57
Plantains ...	13.47	Suhum ...	11.32	Anum	12.34
		Others ...	2.15	Others ...	1.13

PAPER No. XXV.

THE SALE OF FOODSTUFFS IN THE BISA AREA.

By A. S. THOMAS.

INTRODUCTION.

In 1930, a study of the food crops in the Bisa District was commenced, and observations were made on the markets throughout the year, not with the aim to gain complete statistics, but to discover the seasons of harvesting and selling of the various crops. Other aspects of this study are unfinished, but the returns of the markets by themselves are of a certain interest, as they demonstrate the importance of the trade in foodstuffs in the Bisa area.

The district is hilly, and formerly was in the dry forest zone; but the land has been bought by Krobo farmers who have cut down the forests and have planted cacao. At the present time little forest is left, with the exception of strips on some of the hills; and most of the deep soil in the valleys is under cacao.

The food crops are cultivated in various ways :—

1. When new cacao farms are made on land which has been under forest, food crops are interplanted and give a return until the cacao trees commence to fruit.
2. Clearings in secondary bush are made for food farms.
3. Corn and cassava are usually grown separately, either on land which has been used for other food crops, or in places where the soil is too poor for other crops. These foodstuffs are not eaten to any great extent by the Krobos, and therefore are cultivated mainly for sale.

Observations were made on the markets of the three largest towns in the district : at Bisa, which is the most important, as it is at the road head; at Otrokpe; and at Anyaboni.

At each town there are two market days per week; at Bisa, Monday and Friday: at Otrokpe, Monday and Thursday: at Anyaboni, Saturday and Wednesday; in each case the second is the more important market; there are also small sales of various foods on other days of the week, especially at Bisa.

The figures embodied in the paper are the results of counts made in each town on one of the major market days (i.e. Bisa, Friday: Otrokpe, Thursday: Anyaboni, Wednesday) once a month; when possible, at about the middle thereof.

Besides foodstuffs, there are sold at these markets other commodities produced in the Krobo villages—boards of timber, soap (made by boiling the ashes of plantain skins or of cacao husks with palm oil), and sponges (fibres from the stems of *Kohortenye* and *Ayesao*) : these are used in washing. Considerable amounts of cooked foods of various kinds are on sale : and there are large quantities of fish—sun-dried or smoked, brought from the River Volta or from the sea. Cacao, the staple product of the region, is sold in separate markets, or to brokers in the villages.

Attendance at the markets is a great feature of Krobo life, and they form important social centres. Often most of the members of a family will go to market, the produce for sale being carried on the heads of the various individuals, but more especially by the women and children. Most of the money from the sale of foodstuffs is kept by the women and is used for the purchase of dried fish, salt, cloths, utensils, soap, kerosene and other household necessities. But the profits from the sale of yams, corn, palm oil and palm wine usually are taken by the men.

It is estimated that the markets at Bisa, Otrokpe and Anyaboni are supplied with produce from an area of about 200 square miles. Foodstuffs are carried to Bisa market from villages as much as 15 miles away ; when the distance is so great, a start is made before day-break, and it is dark before a return is made to the village.

In November, 1930, a new road was opened to Sekasua, a village west of Bisa, and the market there became of great importance—a count made in January, 1931, showed that it was as large as that of Bisa.

Undoubtedly, produce which would have gone to the markets at Bisa and Otrokpe was deflected to this place ; but returns from Sekasua are not included as the market absorbed also produce which formerly had been sold at Kapli. Anyaboni market, too, was affected by the opening of the Sekasua Road, as it was held on the same days as that of Sekasua.

After sale, the foodstuffs are taken by lorry to other centres, and there retailed ; on two or three occasions the drivers of the lorries were questioned as to their destination ; from their replies it was computed that the produce from Bisa is distributed thus :—

Odumase, Somanya, Akuse, Kpong ...	60 per cent.
Koforidua	25 per cent.
Akwapim	9 per cent.
Accra	6 per cent.

QUANTITIES.

The numbers shown in Table I are those of the head-loads of foodstuffs sold in the markets ; such loads are bigger than those generally carried by one person, for usually they are divided among the members of a family and are assembled in the market.

TABLE I.

Total Numbers of Head-loads and Total Values of Foodstuffs in Anyaboni, Otrokpe and Bisa Markets.

Month, 1930.	Anyaboni..			Otroke.			Bisa.			Total Value.
	Day of Month.	No. of head-loads.	Value.	Day of Month.	No. of head-loads.	Value.	Day of Month.	No. of head-loads.	Value.	
			£ s. d.			£ s. d.			£ s. d.	£ s. d.
April	16	488	70 1 0	17	794	168 10 0	25	1,546	244 6 3	482 17 3
May	14	398	67 12 0	15	853	167 6 9	16	1,927	289 17 6	524 16 3
June	11	588	54 19 9	12	1,167	279 17 0	13	2,045	297 15 6	632 12 3
July	9	535	74 0 9	10	1,265	360 0 6	11	2,396	466 9 0	900 10 3
August	13	598	121 7 9	14	936	262 12 0	15	2,447	484 19 9	868 19 6
September	17	638	104 4 9	18	1,001	176 7 6	19	1,982	319 0 2	599 12 5
October	15	501	83 9 0	16	831	175 3 9	17	2,027	327 3 6	585 16 3
November	19	521	64 5 3	20	778	149 2 9	21	1,884	279 9 8	492 17 8
December	17	241	23 17 5	18	610	102 3 1	19	1,390	192 6 3	318 6 9
1931.										
January	14	232	28 8 6	15	462	87 7 1	16	1,207	134 16 9	250 12 4
February	11	399	35 18 11	12	443	77 13 6	13	1,727	190 9 6	304 1 11
March	4	313	24 0 5	5	446	63 5 10	6	1,022	120 7 0	207 13 3
Total	—	—	£752 5 6	—	—	£2,069 9 9	—	—	£3,347 0 10	£6,168 16 1

Plantains and coco-yams are heaped on flat brass pans : corn, vegetables and fruit are in large baskets woven from strips of the midribs of palm leaves : palm oil is usually carried in four-gallon kerosene tins : palm wine is in large earthenware pots.

Typical head-loads of the various foodstuffs as sold in the markets were found to weigh as follows :—

Plantains	... 60 lbs.	
Coco-yams	... 80 lbs.	
Yams ...	... 70 lbs.	(when scarce, sold in smaller lots).
Corn ...	... 65 lbs.	
Peppers	... 20 lbs.	
Garden eggs	... 45 lbs.	
Palm fruits	... 65 lbs.	
Cow-peas	... 70 lbs.	

In Table II are shown the figures of a typical market day at Bisa. The variations throughout the year in the quantities of the more important foodstuffs are shown in Diagrams I and II.

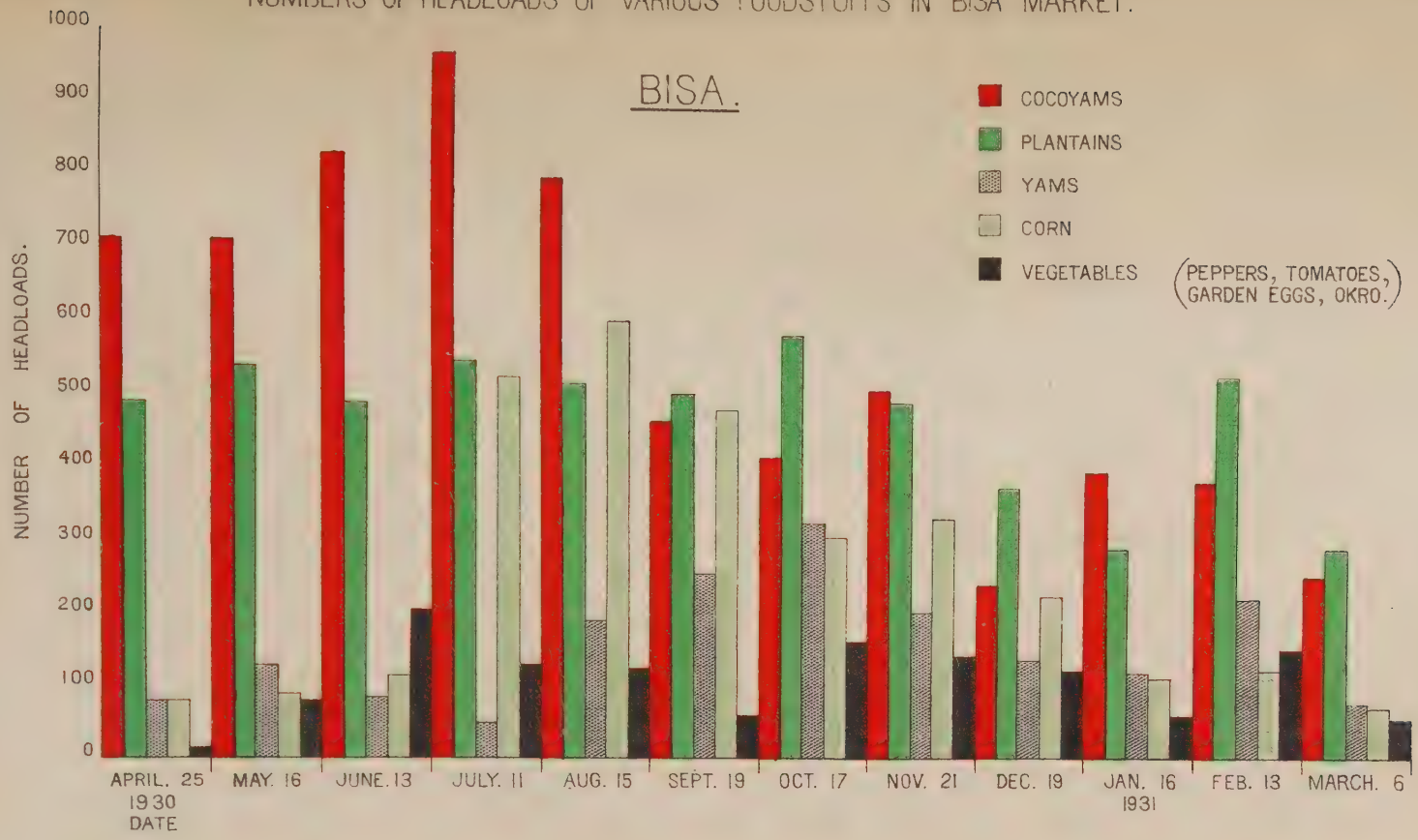
TABLE II.

BISA MARKET (15TH AUGUST, 1930). QUANTITIES AND PRICES.

Foodstuff.	Quantity.	Average price per load.	Value.
			£ s. d.
Coco-yam	796 loads	2/-	79 12 0
Plantain (fresh)	497 loads	1/9	43 9 9
Plantain (dry)	21 loads	1/9	1 16 9
Yam	88 loads	4/-	17 12 0
Forest Yam	100 loads	2/3	11 5 0
Water Yam	1 load	4/-	0 4 0
Yellow Yam	—	—	—
Corn	601 loads	8/6	255 8 6
Peppers	20 loads	4/-	4 0 0
Tomatoes	34 loads	5/6	9 7 0
Garden Eggs	34 loads	3/3	5 10 6
Okro	8 loads	4/-	1 12 0
Cassava (fresh)	37 loads	2/-	3 14 0
Cassava (dry)	42 loads	2/3	4 14 6
Palm fruits	23 loads	4/-	4 12 0
Palm oil	23 tins	6/3	7 3 9
Kernel oil	13 tins	9/-	5 17 0
Palm Wine	38 pots	6/-	11 8 0
Beans (fresh)	7 loads	4/-	1 8 0
Cow-peas	16 loads	9/-	7 4 0
Groundnuts	12 loads	9/-	5 8 0
Oranges	26 loads	1/6	1 19 0
Bananas	—	—	—
Pineapples...	—	—	—
Avocado pears	—	—	—
Green corn	6 loads	4/-	1 4 0
Sugar cane	4 loads	2/6	0 10 0
Mangoes	—	—	—
Total	2,447 loads	—	£484 19 9

DIAGRAM I.

NUMBERS OF HEADLOADS OF VARIOUS FOODSTUFFS IN BISA MARKET.



SURVEY H.Q. ACCRA, 1931.

NOTES ON THE INDIVIDUAL FOOD CROPS.

(The Krobo names are given in brackets.)

Plaintain.

Musa sapientum var. *paradisiaca*, Linn.—(*Mada*) : the bulk of the fruit sold is a variety known locally as *Sosorbuasor*. Plantains usually are sold as fresh fruits—fully grown, but still green ; small quantities are peeled and sun-dried before sale—this being a method of utilisation of any immature branches which are blown over or damaged.

Coco-yam.

Xanthosoma sagittifolium Schott.—(*Amakani*) : it is estimated that about 95 per cent of the tubers sold are of the red-skinned variety (*Amakani tchu*), the remainder being white-skinned (*Amakani hior*).

Yams.

In the Bisa area are grown over 30 different varieties of yams, which locally are classified into four main groups :—

1. Water yam. *Dioscorea alata*. Linn.—(*Alamua*) : the predominant variety is called *Alamua gu*.
2. Yellow yam. *Dioscorea* sp.—(*Kani*) : most of the tubers of yellow yam on sale are of the common type—*Kani gu*, or of the dark-fleshed form—*Kani tchu*.
3. Forest yam. *Dioscorea* sp.—(*Bale*) : the variety *Kati* is the commonest.
4. Ordinary yam. *Dioscorea* sp.—(*Hier*) : nearly all the roots in the markets are those of *Osuban*, which is the most important type.

Corn.

Zea Mays. Linn.—(*Blefo*) : although red-grained and yellow-grained varieties are occasionally grown in Krobo farms, and a quickly maturing white-grained type, *Oloto*, is commonly planted, yet the corn on sale is almost invariably that of a white-grained form, known as *Blefo*. A small quantity of corn is marketed in the ear for use as a vegetable, for which purpose it is picked when the grains are fully grown but have not hardened.

Peppers.

Capsicum. spp.—(*Kwada*) : several large-fruited forms—red or yellow in colour—are sold fresh ; while the type with small red fruits (*Kpesebi*) is sold either fresh or dried.

Tomato.

Lycopersicum esculentum. Mill.—(Tomato, there is no general Krobo name, as the plant is of recent introduction) : the fruits on sale vary greatly in size ; no yellow-fruited types are grown.

Garden Egg.

Solanum melongena. Linn.—(*Ga*) : five distinct forms are to be seen, varying in colour from crimson to orange when ripe, and in shape from spherical to ovoid. The most common type is *Ga hior*, which has large spherical fruits, white when unripe, orange when ripe.

Okro.

Hibiscus esculentus. Linn.—(*Muomi* or *Pui*) : there are two types largely grown on Krobo farms :—

1. *Pui hior*—a short-fruited form which comes into bearing quickly : most of the fresh okro in the market is of this type.
2. *Kromtete*—a slow-maturing variety with long fruits—sometimes sold fresh, sometimes sliced and dried in the sun before sale.

Cassava.

Manihot palmata. Pehl.—(*Agbeli*) : there are many varieties, some of which may be seedling forms ; but all others are being displaced by the heavy-yielding though slow-maturing type known as *Calabar*, which although it was introduced as recently as 1919, yet now is by far the most important variety.

Oil Palm.

Elaeis guineensis. Jacq.—(*Ta*) : there is a certain amount of variation between the produce of individual trees in this district, but most of them can be classed as var. *dura* (var. *macrosperma* Welw.), which when ripe has a red pericarp, tipped with black, and a thick endocarp.

Beans.

Phaseolus lunatus. Linn.—(*Akatramor*) : these are sometimes sold green, in the pod, but more often as dried shelled seeds. A basket of beans in the market usually contains a large admixture of types—self-coloured, white, red, black and brown, together with striped and mottled forms. There is one very distinct variety, perhaps of a different species, known as *Akatramor onanomobor* (i.e. merciful) or *Akatramor owenofor* (i.e. bearing when young) ; this variety quickly matures and has small ovoid buff-coloured seeds.

Cow Peas.

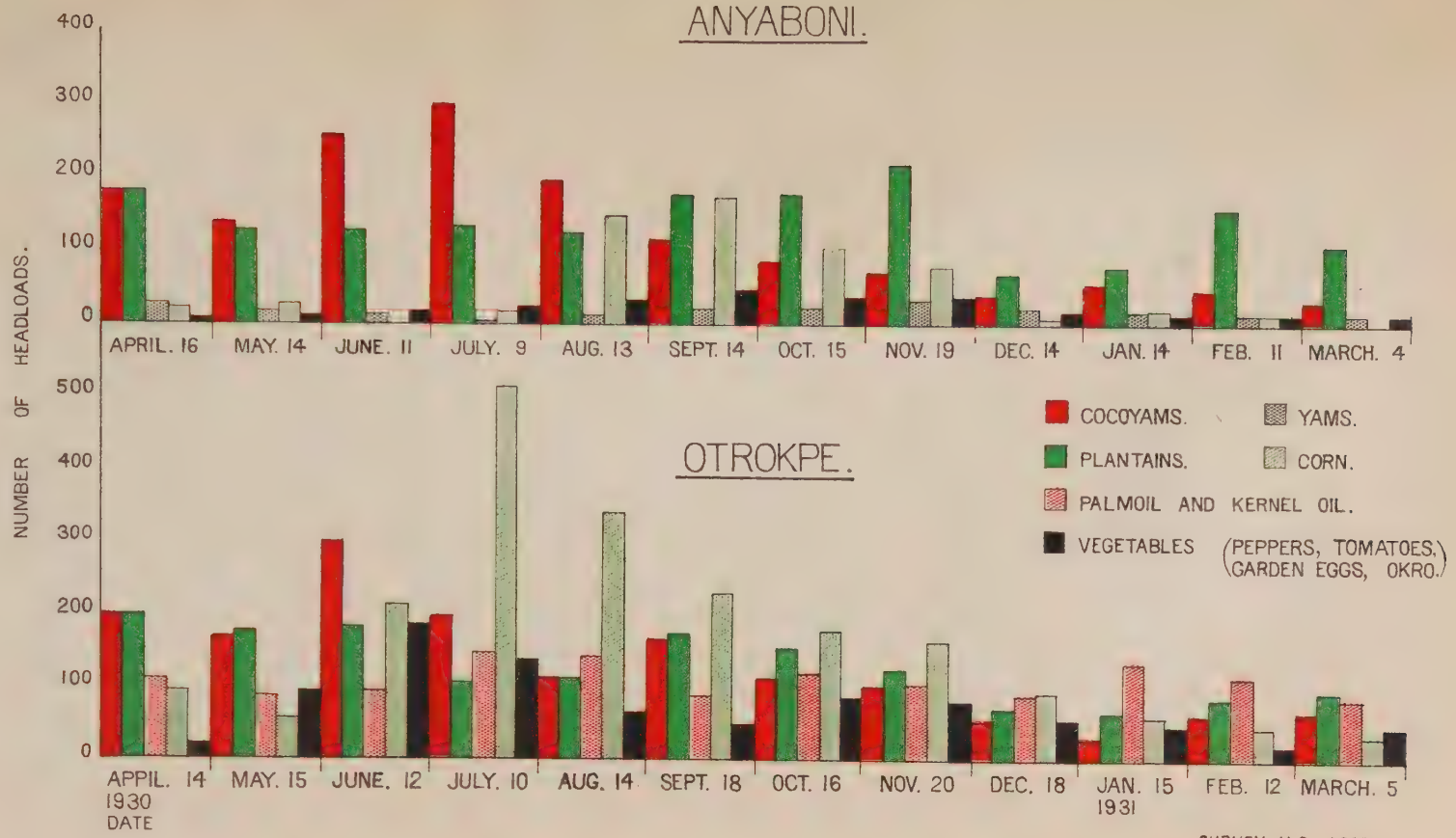
Vigna unguiculata. Walp.—(*Yor*) : the types grown in the Bisa area are all procumbent forms with red seeds, sometimes slightly mottled with black.

Groundnuts.

Arachis hypogea. Linn.—(*Akate*) : are seldom grown inside the forest zone, and the occasional baskets seen in the market are usually brought from Ada region.

DIAGRAM 2.

NUMBERS OF HEADLOADS OF VARIOUS FOODSTUFFS IN ANYABONI AND OTROKPE MARKETS.



SURVEY H.Q. ACCRA, 1931.

Orange.

Citrus aurantium. Linn.—(*Akutu*) : all the trees in the district are seedlings : yet some of them furnish fruits of very good size and flavour.

Banana.

Musa sapientum. Linn.—(*Kodu*) : four different varieties are grown by the Krobos : the fruits in the markets are usually those of the Gros Michel variety—this, like the other forms which have been introduced comparatively recently, is known as *Blefo Kodu* (Europeans' Banana).

Pineapple.

Ananas sativus. Schult.—(*Blefota*—European palm) is never planted in this district, but in some places it is naturalised in large stretches ; from these wild plants the fruits (which are usually yellow, and seldom red) are gathered for sale.

Avocado.

Persea gratissima. Gaertn.—(*Pear*) : a fruit of recent introduction, but very popular : all the trees are seedlings, and in consequence the fruits vary considerably as regards the thickness of the pulp and the degree of purple pigmentation of the skin.

Sugar Cane.

Saccharum officinarum. Linn.—(*Ahleu*) : is grown only in small patches, and is sold in lengths for chewing.

Mango

Mangifera indica. Linn.—(*Mango*) : the fruits are all from seedling trees, and are small and more or less stringy.

PRICES.

No foodstuffs are sold by weight in these markets, but different methods of assessment are employed :—

1. By the head-load or basketful—plantains, coco-yams, yams, dried plantains, dried cassava ; vegetables (sometimes) : palm oil and kernel oil per 4-gallon tin (sometimes in bottles).

2. By measure—corn, palm fruits (per small enamel basin—approximately ⅔ pint), cow-peas, dried beans, groundnuts (per cigarette tin).

3. By count—vegetables, fruits, cassava roots.

The markets at Bisa, Otrokpe and Anyaboni are largely wholesale : foodstuffs are often retailed in smaller quantities and at higher prices.

The hold-up of cacao during November and December, greatly reduced the amount of money in circulation, and consequently it caused a depression in the prices of all foodstuffs; but it is probable that there is also a seasonal variation in prices, owing to the fluctuations in the quantities of various products for sale.

On Diagram 3 are shown the prices throughout the year of plantains, coco-yams and corn, the three most important commodities; the prices of the fruits and vegetables varied to an even greater extent. For example, the price of oranges fell from 3–6 per 1d. in April, 1930, to 20–25 per 1d. in January, 1931; after which date the price again rose to 8–12 per 1d. in March, 1931. Vegetable prices showed fluctuations as great or greater, and the quality varied greatly according to the season—the tomatoes and garden eggs for sale in March and April, are not only much more expensive, but also are of much poorer quality, than those sold in June and July.

The estimated aggregate values of the foodstuffs sold in the three markets are shown in Table I. These figures are as accurate as possible; for some commodities, e.g. plantains and coco-yams, the computation was simple—it was only necessary to count the number of head-loads and to ascertain the average price: for corn, the number of measures in an average basketful was found, and from the price per measure, a mean value per head-load was calculated; for vegetables the computation was more difficult—some were sold per head-load, some in small quantities.

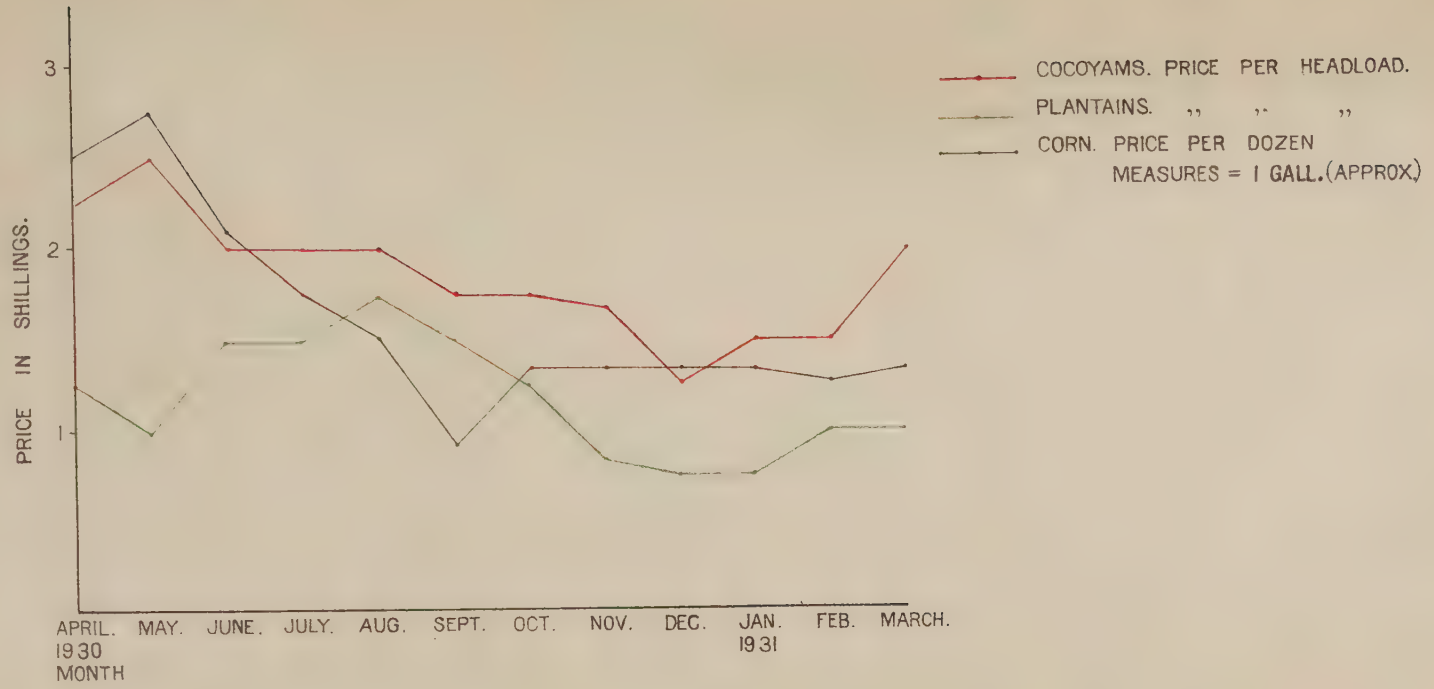
At each market the greatest aggregate values were reached when the product of the main crop of corn was brought for sale—at Otrokpe during June, July, August: at Bisa during July and August: at Anyaboni during August and September. The time when the crops mature is determined by the time of sowing, and this is governed by the incidence of the rains; for in 1930, there were considerable rains in the neighbourhood of Otrokpe before there were any near Bisa, while the villages which supply Anyaboni market did not have rain until very late.

The diminution in values towards the end of the year would appear to be partly seasonal, and partly due to two complicating factors—the deflection of produce to Sekasua consequent on the opening of the road to that place, and the drop in prices caused by the hold-up of cacao.

Even with these disadvantages the total trade in the three markets on the days observed was £6,168—giving an average for the three markets of nearly £514 per week throughout the year. As stated above, there was in every town another market-day each week, and in addition, small amounts of foodstuffs were sold in the towns every day. A conservative estimate would place the aggregate of sales on the other days of the week as being half

DIAGRAM 3.

AVERAGE PRICES OF COCOYAMS, PLANTAINS AND CORN AT BISA MARKET.



SURVEY H.Q. ACCRA, 1931.

that on the main market day. On this assumption the total weekly trade in these towns would amount to £514 + £257 = £771, or approximately £40,000 per annum ; and this is from an area of just over 200 square miles, an area of which all the best of the land is under cacao plantations.

FINANCIAL RETURNS FROM THE CULTIVATION OF FOOD CROPS.

Prices of foodstuffs are relatively high, and the returns from the growing of foodstuffs seem to be excellent.

For example; Coco-yams at 1s. 9d. per 80 lbs. load are worth £2 9s. per ton : the actual yield per acre in this district is unknown, but from the results of trials in other countries (1) it is probable that four tons per acre is a low estimate ; at which cropping coco-yams would give a return of £9 16s. per acre.

Corn at 8s. per load of 65 lbs. is worth about £13 15s. per ton (c.f. the London price (February, 1931) 16s. per quarter of 480 lbs. = approximtely £3 15s. per ton) the average yield on native farms in the Central Province is over 14 cwt. per acre (2) ; at which figure the produce of one acre would be worth £9 12s. 6d.

Such returns compare very favourably with those from cacao in times of depression ; cacao yielding 595 lbs. per acre (3) and sold at 10s. per 60 lb. load produces £4 19s. per acre.

Because of the low price of cacao there is at present much discussion concerning the possibilities of an alternative crop. Yet large quantities of foodstuffs are imported into the Gold Coast from French Togoland (4) and by sea—including in 1930 over £200,000 worth of rice ; not only the towns, but also some of the cacao-growing areas, are supplied with food from other districts.

SUMMARY.

1. An account is given of the sale of foodstuffs in the Bisa area ; this account being founded on returns of the markets at Bisa, Otrokpe and Anyaboni, made once a month throughout the year April, 1930—March, 1931.
2. The returns to be obtained from the cultivation of food crops in the Gold Coast are discussed.

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PAPER No. XXVI.

NOTES ON FOOD FARMING AT EJURA.

By T. HUNTER and T. V. DANSO.

During 1930, Mr. Danso, African Overseer, was engaged in working amongst the farmers and in collecting information to find out what could be done regarding the stimulation of food-crop production. His records form the basis of this paper.

This officer, being well known to the people, has been able to carry out a careful survey of the farms and to weigh and value the crops thereon without raising any suspicion amongst the farmers. When an officer is not well known to the people, this suspicion often leads to unreliable information being obtained.

AGRICULTURAL CONDITIONS.

The land around Ejura is situated in the open savannah country, just outside the forest zone. The soil generally is a sandy loam, with a fairly well drained subsoil. Gentle undulations also occur, thus further assisting drainage. Experience has shown that the land in general is capable of supporting annual crops from which good yields may be expected.

CLIMATIC CONDITIONS.

The rainfall, as shown in the attached table, shows two well-defined rainy periods, "April, June" and "September to November"; these periods suit the cultivations and, particularly allow for the cultivation of two maize crops annually. The area is subjected to rather severe *harmattan* during the month of January.

Rainfall at Ejura.

Month.	1930.	Average for 12 years.
	inches.	inches.
January	.15	.56
February	.95	2.03
March	2.09	4.46
April	6.58	5.36
May	13.17	7.25
June	7.82	7.56
July	3.50	4.23
August	.64	2.69
September	8.56	9.21
October	7.23	8.20
November	5.63	4.52
December	.18	1.07
	56.59 inches.	57.14 inches.

RECENT ECONOMIC DEVELOPMENT.

Formerly, food crops were grown in this area almost entirely to supply the needs of the local population. With the completion of the road to the Northern Territories in 1924, resulting in increased transport facilities, the cultivation of food crops was greatly accelerated, and now, considerable quantities of food crops, particularly yams, are grown to supply the Kumasi and other markets. The down traffic from the Northern Territories is very light, consequently, in order to obtain freights at Ejura for the last stage of the journey, food crops, particularly yams, are carried at very low rates, and this factor has also helped in the increase of the traffic in food crops.

CROPS GROWN.

The cultivation of food crops in the area has been carried on for generations. The main crops grown are yams, maize, groundnuts and rice ; other crops are cassava and numerous small crops usually grown as catch crops. This paper deals with the four principal crops : yams, maize, groundnuts and rice.

METHOD EMPLOYED IN THE AGRICULTURAL SURVEY.

The system adopted in carrying out the agricultural survey was that of visiting each farmer's farm, roughly measuring the area of each, recording the crops grown, system of cultivation adopted, and in certain cases recording the weights of crops produced by weighing the produce from a measured portion of the farm and calculating the yields per acre for each crop grown.

A house-to-house visit was also carried out, and records made as to the actual number of residents, from which the census of population was obtained. This gave a further check on the actual number of farmers and ensured that each farmer's holding had been visited.

POPULATION AND AREA CULTIVATED.

The census shows a total population of 2,123, of which 731 are men, 621 women and 771 children. The number of farmers cultivating food crops at Ejura is 270 ; these farmers own farms of a total acreage of 1,049 acres with an average of about 3.38 acres per farmer. Of the above, 11 farms comprising 51 acres are not dealt with in the crops under discussion.

There are two main types of farmers. The Ashanti natives number 69 and the Northern Territory settlers number 147, the remainder belonging to various tribes. The Dagombas, one of the Northern Territory tribes, make up more than 25 per cent of the farming community, and are particularly fine farmers.

METHODS OF FARMING AND OF CULTIVATION.

The system of farming, as generally practised, consists in cultivating the land for a period of two or three years and then allowing it to lie fallow for four or five years. The mixed cropping system as practised in some parts of the country is not so common in this district. Yam farms are sometimes interplanted with corn, rice, or beans, as a late crop when yams are nearing the time for harvesting, but these must be considered as catch crops rather than a definite system of mixed cultivation. Even the Dagomba farmers, who in their own country carry out an elaborate system of mixed cropping, work on the single-crop system at Ejura.

Cropping Table.

	A. *Ashanti Natives.*	*B.* *Northern Territory Settlers.*
1st year—	Yams	Yams.
2nd Year—	Groundnuts (early crop)	Corn (early crop).
	Corn or rice (late crop)	Corn or rice (late crop).
3rd Year—	... ...	Corn (early crop), Corn (late crop).

YAMS.

The yam crop is of considerable importance, being the main source of food for the local people. The surplus crops, which are easily disposed of, now form a profitable industry, quite three-quarters of the crop being sold to supply Kumasi and other markets. There is room for considerable expansion in yam cultivation, both here, and in other parts of Northern Ashanti.

CULTIVATION.

The farmer shows a marked tendency towards new soil for yam cultivation, which would not appear to be entirely due to the virgin soil being richer ; it is easier to work the newly cleared ground into yam mounds than it would be to dig the soil for maize or groundnuts, and ground for the latter is more easily prepared from the yam mounds than by digging fresh grass land. The ground is cleared some time before the mounds are made in order to allow the grasses to die down and rot. Sometimes a late crop of corn is grown on the area, but these late crops are rarely good.

The cultivation of yams shows the local farmer at his best. He goes to considerable trouble to make his yam mounds, and the feature of a yam farm is the spacing, which is usually carried out with precision. The approximate distance at which yams are planted is 5′ × 5′.

Yams are planted from November to January by Northern Territory farmers and as late as March by Ashanti farmers. Apart from staking and weeding no further cultivation is given. The different varieties mature at various periods from June until November. When the land is not immediately required the late crop varieties are left in the soil during the dry season. All are harvested before the rains commence in February.

The Ashanti farmers, owing to native custom, are unable to harvest their yams until after the Yam Festival in December. This makes a later crop and in this case planting is done in February and March. These late plantings are stated to be of poorer quality although the same variety of yam may be used as the crop which is planted and matures earlier.

HARVESTING.

The method of harvesting practised by Northern Territory farmers is to remove the tubers from the mounds in the course of development, leaving the roots intact, which later form smaller tubers known as seed yams. The number of first tubers per mound varies from one to three, rarely more. In the case of Ashanti farmers, for reasons mentioned above, the tubers, remain until the plants are mature.

Single tubers are much larger, and, from observations made during weighing, the yield per acre from single tubers would appear to be much about the same as when more tubers per mound are produced. The smaller tubers being of a fairly even size are more popular and are more convenient in fixing the price when marketing.

STORAGE.

No elaborate system of storage is practised, the farmer mainly depending on harvesting and selling the different varieties as they mature, replanting the seed yams soon after the latter are harvested.

VARIETIES GROWN.

The table on page 220 gives a description of the different varieties grown, their quality and planting dates. The comparative yields and values were obtained from various records made while testing the different varieties on the old Agricultural Station.

YAM VARIETIES.

Variety.	Colour.	Date planted.	Date of harvesting.	Yields per Acre.	Value.	Remarks.
1. Lareboko	White ...	November	May-October ...	2 tons ...	£7 per ton	Very early; quality excellent.
Durse	White ...	November-January ...	June-October ...	4 tons ...	£4 per ton	Quality fair.
3. Pasadjo	White ...	November-January ...	June-October ...	4½ tons ...	£4 per ton	Quality good.
4. Puna	White ...	November-January ...	June-October ...	3 tons ...	£4 per ton	Quality fair.
5 Akokoayan	White ...	November-January ...	June-October ...	3½ tons ...	£4 per ton	Quality fair.
Lilia	White ...	November-January ...	October-December	4½ tons to 5 tons.	£4 per ton	Main crop quality good.
7. Zon	White ...	November-January ...	October-December	4½ tons ...	£4 per ton	Main crop quality good.
8. Kagbaranga ...	White ...	November-January ...	October-December	3½ tons ...	£4 per ton	Main crop quality good.
9. Gyindi Dushi ...	White ...	November-January ...	October-December	3½ tons ...	£4 per ton	Main crop quality good.
10. Sermanu	Red	November-January ...	October-December	3 tons ...	£4 per ton	Main crop quality good.
11. Krukrukpa	White ...	November-January ...	October-December	2½ tons ...	£4 per ton	Main crop quality good.
12. Asobayere	White ...	November-January ...	October-December	1½ tons ...	£7 per ton	Main crop quality very good.
13. Nyinebi	White ...	January-March ...	June-February ...	3 tons ...	£4 per ton	Main crop quality very good.
14. Zugulamgbo ...	White ...	January-March ...	June-February ...	2 tons ...	£4 per ton	Quality fair; good storage variety.
15. Brofo	Red	January-March ...	June-February ...	3 tons ...	£3 per ton	Quality fair; good storage variety.

Yields of Yams.

The following table gives the actual weight of fresh tubers produced from measured areas on farms at Ejura.

Area of Plot.	Yield per Plot in lbs.	Estimated yield per Acre in lbs. (Fresh tubers.)
½ Acre	3,080	6,160
¼ Acre	2,352	9,408
½ Acre	5,051	10,102
¼ Acre	2,772	8,316
¼ Acre	1,788	7,152
⅛ Acre	3,676	11,028
¼ Acre	3,416	10,248
⅛ Acre	2,614	6,968
¼ Acre	2,422	9,688
Total	27,171	79,070
Average in lbs.	3,019.2	8,785.5
Average in tons	1.35	3.92

The above records were taken from main crops, chiefly *Lilia* and *Zon* varieties.

Market Values.

Yam tubers vary in size and weight even in the same variety. The average number of saleable tubers per cwt. based on weighing several lots of yams works out at 12 to 16 per cwt. Some tubers weigh as much as 20 to 28 lbs., the latter weight being rarely exceeded in this district. These larger yams are sold separately.

Yams sell readily at 4s. per cwt. and this price appears to be satisfactory to the farmers. The value of the yam crop at Ejura at 4 tons per acre and £4 per ton would therefore be approximately £7,000, three-quarters of the crop is sold, the remaining one-quarter being used for local consumption.

The varieties cultivated are grouped in distinct classes which are early, mid-season and late. The early varieties do not keep well and often result in poor germination. The very late varieties although poorer in quality are grown because of their better keeping qualities. The varieties *Pasadjo* (3), *Lilia* (6), *Zon* (7) are the most popular and bring in the best returns; quite 60 per cent of the crop grown being these three varieties.

This selection of varieties according to season is similar, though on a smaller scale, to what happens with the potato crop in Europe. It further enables the farmer to keep up regular supplies without troubling about storage, which is a difficult problem.

The varieties *Lareboko* (11), and *Asobayere* (12) are sold separately in the market owing to their superior quality and smaller size. The varieties *Zugulamgbo* (14), and *Brofo* (15) are not of very

good quality, but are grown for the sake of their good storage properties and are not mixed on the market to depreciate the value of others. No distinction is made when selling other varieties, the sizes of which are more or less even and quality much about the same.

MAIZE.

The area under cultivation grown as a single late crop was 381 acres; approximately 50 per cent of the yam lands were also planted with corn on the yam mounds as a late crop, the Ashanti white type of maize being the variety grown.

The Northern Territory farmers usually plant maize in the second and third years of cropping, and two crops are grown each year, following yams planted the first year. The third year's farming has only been adopted in recent years, since farming operations have extended owing to the increase in yam cultivation, and the fact that suitable land is not so easily obtained as formerly.

Cultivation.

The early maize crop when grown as a pure stand is planted in early March, and harvested in July, and the late maize crop is planted in August and September and harvested in December and January. When grown as a catch crop on yam farms it is planted on the yam hills in September.

The maize is grown on ridges 5 feet apart and the seed is planted 3 to 4 feet apart, one to three plants to a stand being allowed to grow. The ridges usually follow the yam lines where this crop has been previously grown, and to a large extent account for the wide spacing of maize lines, although farms are to be seen on newly-cleared ground where the same wide spacing exists.

The ridge system is preferred to the flat, not only for the purpose of assisting drainage, but the making of ridges is also considered easier than digging on ordinary flat ground. Observations show that, under the native system of digging with a small hoe, this is true, and that the grass roots are more easily extracted from the soil, particularly where Lalang is present.

Harvesting and Storage.

The maize is usually left in the field until the ears are dry and then harvested. The maize ears are usually stored in barns 4 feet off the ground, beneath which fires are occasionally lighted, in order to keep away grain pests.

Yields.

No survey was carried out on the first crop of maize, and the yield from only one farm was taken. This was a farm above the average for the district and gave a yield of 904 lbs. of shelled maize to the acre.

Flying swarms of locusts unfortunately attacked the corn farms in the district during November, 1930, and destroyed the late crops, thereby preventing a record of yields being made from a number of farms as intended. One of the Dagomba Chiefs' farms, two acres in extent, escaped destruction ; this was well up to average for local maize, and two of the best sections, consisting of one-eighth of an acre each, were selected, the crop harvested, and the grain weighed with the following results :—

Area.	Distance apart.	Yield of Maize.	Yield per Acre. (Dry Grain).
⅛ Acre	5′ × 4′	87 lbs. dry grain	696 lbs.
⅛ Acre	5′ × 4′	72 lbs. dry grain	576 lbs.

The land was cleared and carried yams in 1929 and two crops of corn in 1930.

The above yields are about the usual average for first and second crop planting in the area. The first crops are rather better and give an increased yield of 300 to 400 lbs., which gives an average yield on native farms of about 950 lbs. for the early crop and 600 lbs. for the late crop. The latter average yields for corn on native farms were recorded some years ago by the Superintendent of Agriculture in the district* and agree with the records now made.

The local price of corn is 6s. per cwt. and 50 per cent of the crop is consumed locally.

RICE.

The area under rice cultivation as a single crop is 38.25 acres ; 116 acres were also cultivated between yams as a catch crop. The local upland variety of " red rice " and " *pindi* " varieties are grown in the area.

Cultivation.

Rice is planted in July and August and harvested in December. It is usually grown on ridges 1½ feet apart, the ridges being about 2 feet wide and the seed planted 6 inches apart in three lines on the ridges. Weeding and stirring are practised twice during the growing period.

Yields.

The yields of paddy rice were obtained from six farms, three of which show the yield as a single crop and three as a catch crop between yams.

*Caldwell's reports to Director of Agriculture, 1922.

Yields as a Single Crop.			Yields as a Catch Crop.		
Area	Yield.	Yield per Acre.	Area.	Yield.	Yield per Acre.
¼ Acre	224 lbs. ...	896 lbs.	1⅓ Acre	450 lbs.	336 lbs.
¼ Acre	147 lbs. ...	588 lbs.	1⅔ Acre	822 lbs.	493 lbs.
¼ Acre	228 lbs. ...	912 lbs.	1½ Acre	391 lbs.	294 lbs.
¾ Acre	599 lbs. ...	2,396 lbs.	4½ Acre	1,663 lbs.	1,123 lbs.
Average per Acre		798 lbs.	—	—	374 lbs.

The local market value of rice paddy is 16s. per cwt. and most of the crop is sold.

GROUNDNUTS.

The Northern Territory farmers do not cultivate groundnuts to any extent. In 1930, 47 Ashanti farmers cultivated 118 acres. Many farmers also grow very small areas as a catch crop for their own use; these areas are not included in the survey. The procumbent native variety is usually grown but a few farmers show a preference for the erect or Zaria type of groundnuts.

Cultivation.

Groundnuts are planted in March and harvested in June and July. The ridging system of cultivation is practised and, in addition to reasons mentioned under maize cultivation, it is obviously much easier to harvest the groundnuts from ridges than from flat ground. The groundnuts are planted 1 foot apart on the ridges. Harvesting is usually carried out by women and children.

Yields.

Area.	Yield in lbs.	Yield per Acre in lbs.
2 Acres ...	1,172	586
2½ Acre ...	1,440	576
½ Acres ...	238	476
Total ... 5 Acres ...	2,850	1,638
Average per Acre ...	—	546 lbs.

The local market value of groundnuts is 8s. per cwt. and most of the crop is sold.

ANALYSIS OF DATA.

The following data are given regarding the area under cultivation and yields. All were grown as single crops :—

Crop.	Area in Acres.	No. of farmers.	Average per farmer.	Yield per Acre (approx.)	Local values per ton.
Yams	464	206	2.2	4 tons	£4—fresh tubers.
Maize, late crop	381	184	2.1	630 lbs.	£6—dry grain.
Rice	38	25	1.5	800 lbs.	£16—paddy.
Groundnuts ...	115	47	2.5	550 lbs.	£8—unshelled nuts.

The above table does not include 232 acres of maize and 116 acres of rice grown as catch crops between yams. The yields per acre have been estimated from actual records of native farms, as given in previous paragraphs.

The size of individual farms ranged from less than half an acre to 30 acres distributed as follows :—

Size of farm	No. of farms.	Yams Acres.	Corn Acres.	Ground nuts Acres.	Rice Acres.	All four crops Acres.
1 acre and under ...	58	25	12	9	1	47
Over 1 acre up to 2 acres	73	52	50	24	7	133
Over 2 acres up to 3 acres	28	40	28	9	2	79
Over 3 acres up to 4 acres	24	36	45	9	3	93
Over 4 acres up to 5 acres	21	47	40	8	4	99
Over 5 acres up to 8 acres	29	89	80	16	9	194
Over 8 acres up to 10 acres	10	51	33	7	4	95
Over 10 acres up to 15 acres	9	52	55	15	—	122
Over 15 acres up to 20 acres	6	52	28	18	8	106
Over 20 acres	1	20	10	—	—	30
Total	259	464	381	115	38	998
Average per farm		1.79	1.47	0.44	0.14	3.86
Average cropping of 1 acre ...		0.46	0.38	0.12	0.04	1.00

The actual composition of the individual farms over 15 acres was as follows :—

Yams Acres.	Corn Acres.	Groundnuts Acres.	Rice Acres.	All four crops Acres.
3	8	2	3	16
7	5	—	5	17
12	4	$2\frac{1}{2}$	$\frac{3}{4}$	$19\frac{1}{4}$
$7\frac{1}{2}$	2	8	—	$17\frac{1}{2}$
20	10	—	—	30
12	—	6	—	18
10	$8\frac{1}{2}$	—	—	$18\frac{1}{2}$

COST OF CULTIVATING VARIOUS CROPS AT EJURA.

In addition to enquiries made direct from farmers themselves, observations were carried out on certain farms noting the labour employed and the amount done by the farmer himself, from which the following table of costs is obtained. It was impossible to get in money the exact working costs as they vary so much, therefore, the costs are worked from the units of labour employed.

The costs for rice cultivation were not obtained but these would appear to be much the same as for corn cultivation.

The actual labour usually employed, except on large farms, is used in clearing and burning for planting, and weeding, the farmer and his family doing the rest of the work themselves.

COST OF CULTIVATING CROPS AT EJURA (NATIVE FARMS).

Crop.	Preparation.	Planting.	After cultivation.	Collecting stakes.	Staking, etc.	Harvest.	Total man days per Acre.
Yam ...	33	8	15	22	8*	18	104
Corn ...	23	2	10	—	—	6*	41
Groundnuts	24	6	12	—	—	37*	79

*Cost of staking yams and harvesting maize and groundnuts based on Agricultural Station records. Cost of clearing included under yam cultivation.

The total average cost of production (based on six years working) on the old Agricultural Station for plots under continuous cultivation was as follows :—

COSTS (OLD AGRICULTURAL STATION).

Crop.	Preparation.	Planting.	After Cultivation.	Collecting stakes.	Staking, etc.	Harvest.	Total man-days per Acre.
Yam ...	24	10	33	22	8	12	109
Maize ...	24	4	17	—	—	6	51
Groundnuts	26	12	13	—	—	37	88

In the above table, the cost of clearing grass land for yams and of decorticating groundnuts is not included. Labour was paid at the rate of 1s. per day.

COMPARISON OF COST OF PRODUCTION AND REVENUE FROM CROPS (NATIVE FARMS).

Crop.	Cost in man-days per acre.	Average Yield per acre in lbs.	Cost of Crop in man-days per lb.	Market value per lb.	Value of crop per acre.	Monetary return per man-day.	Condition of crop.
					£ s. d.		
Yam ...	104	8,785	.01	.429d.	15 14 1	36.2d.	Clean tubers
Maize ...	41	636	.06	.643d.	1 14 1	10.0d.	Dried grains
Groundnuts	79	546	.14	.857d.	1 18 10	5.9d.	Undecorticated nuts.

CONTINUOUS CROPPING VERSUS SHIFTING CULTIVATION.

The above results indicate that the yields must be considered fair average yields for native farms, but are rather low when considered as single crops.

In the Year-Book for 1929, page 180, the results of continuous cropping, over a period of six years, in a rotation on the old Ejura Station show that continuous cropping did not lead to reduced yields, in fact all crops showed in the second cycle (of three years) that the cropping was as heavy as in the first cycle.

The average yields of crops from native farms when compared with these results show strongly in favour of continuous cropping.

	Mean yields 6 years cropping at Ejura Agricultural Station.	*Native farms Recorded in 1930.*
Yams	10,057 lbs. per acre	8960 lbs. per acre.
Maize (early crop,) ...	1,332 lbs. per acre	904 lbs. per acre.
Groundnuts ...	1,078 lbs. per acre	546 lbs. per acre.

It is recognised that seasonal variations and the fact that records were not available from local farms during the cropping periods of the Departmental rotation, render this comparison open to criticism ; at the same time the following facts should not be overlooked :—

(a) The rainfall for the year 1930 was well up to average.

(b) The crops for 1930, on native farms, were considered by the farmers themselves to be well up to average.

(c) During 1930 a demonstration with late maize on the old rotation site gave the following yields ; showing that much heavier yields can be obtained.

MAIZE YIELDS ON OLD ROTATION PLOT.

Spacing.	Area.	Yield in lbs.	Yield per acre (lbs.).
(1) 3′ × 1½′	¼ Acre	422	1,688
(2) 3′ × 3′	¼ Acre	424	1,696
(3) 3′ × 2′	⅛ Acre	259	2,072

(d) The farmer after all is the best critic, and the conclusions drawn by him explained as follows, must not be ignored.

The disadvantages of shifting cultivation are well understood and in all progressive countries such methods have been abandoned, in favour of continuous cropping. The farmers at Ejura are now realising this and, that under shifting cultivation, the pernicious weed Lalang, *Imperator* sp., is making great headway on fallow land. They agree that continuous cultivation decreases this troublesome pest.

The higher yields on our rotation trial plots is no doubt in some measure due to better methods of cultivation ; at the same time the local farmers are no mean cultivators and there is reason to believe that the increased yields are to a large extent due to green manuring, which was practised throughout the rotation.

Despite all the methods of cultivation which the farmer has found for himself, green manuring does not appear to have received any consideration.

With the increasing demand for food crops and the consequent bringing in of larger areas under cultivation, areas free from Lalang infestation are more difficult to obtain. This is already reflected in the fact that the farmer is extending the periods of cultivation on these areas. Where formerly he rarely occupied the land for more than two years he now very often remains for a third year.

The farmer is already beginning to realise that he may get better results by adopting our methods, and lack of suitable areas free from Lalang infestation makes him desirous of trying a more continuous system of cultivation on the areas where this pest does not occur.

At their own request six farmers have been provided with green manure seeds, and each is planting half an acre of land under our supervision, where yams were grown last year. The land is to be cultivated with a late crop of corn so that each farmer may see for himself the benefits to be derived. It follows that the land will receive more cultivation when digging in the green manures than it does at present. This will naturally lead to beneficial results.

POTENTIALITIES OF THE DISTRICT.

It will be seen from the foregoing that the cultivation of food crops, particularly yams, is a lucrative occupation, and that the area is capable of considerable development. This is further evident from the increasing number of Northern Territory settlers in the area during recent years.

Transport conditions are excellent because the area is situated on the North Road, which provides a cheap means of transporting the crop to Kumasi.

A recent test made by one of the leading firms showed that yams can be delivered at Kumasi at 5s. 3d. per cwt. and, after paying 3s. 3d. per cwt. railway freight, can be placed on the market at Accra at quite 40 per cent below the retail prices charged in that market. At Sekondi and Takoradi the prospects were better, and the landed price was over 50 per cent below the market value.

With the reduction in railway freights on yams, which is now being considered, it is certain that there are extensive available markets for this crop, which should bring about a reduction in price to the consumer, an increase in the demand, and at the same time assure for the producer a satisfactory return for his labours.

PAPER No. XXVII.

AGRICULTURE IN THE NAVRONGO AND ZUARUNGU DISTRICTS OF THE NORTHERN TERRITORIES OF THE GOLD COAST.

By J. C. MUIR and T. LLOYD WILLIAMS.

INTRODUCTION.

This report, dealing with agriculture in the Navrongo and Zuarungu Districts of the Northern Territories of the Gold Coast, is based on observations and enquiries made by the writers during part of one farming season. The districts are merely self-supporting, no crops being grown for sale other than in local markets. The report is therefore simply a general description of the method of farming which the people of these districts employ to provide for their limited requirements. The method is unusual in this country in that farmers employ permanent cultivation to a much greater extent than shifting cultivation in the growing of annual crops.

Vegetation.

Navrongo and Zuarungu Districts lie in what is commonly described as orchard country. More accurately they occur in zone ranging from the Acacia Tall Grass Savannah to the Acacia Desert Grass Savannah of Shantz and Marbut's classification. (1)

Rainfall.

The mean rainfall over a period of years is approximately 40 inches at Navrongo and 43 inches at Zuarungu, with a considerable and uneven annual fluctuation. There is a rainless period of five to six months in every year during which an arid wind the *harmattan* blows from the North-East causing the growth of most plants to be suspended.

Characteristic Tree Flora.

The characteristic tree flora of the districts consists of :—

Acacia spp.
Terminalia spp.
Combretum spp.
Zizyphus spp.
Butyrospermum Parkii.
Parkia filicoidea.
Adansonia digitata.

In the more cultivated parts, the last three are the dominant features of the landscape, and provide an appreciable part of the food of the people.

Soils.

Soils vary markedly in colour and in texture. In general they are light and shallow; the subsoils range between shales and heavy clays. Patches of deep dark-red soil occur but the more common soils, grey to light red in colour, appear to be derived from granitic rocks, many outcrops of which are present. Numerous soil samples have been taken and the soil reaction tested. In most cases this is neutral or very slightly acid ranging from pH 7.0 to pH 6.7. Only in the case of one type, a fine silt, light-grey when dry and dark grey when wet, is there frequently an acid reaction (pH 6.0).

Land Tenure.

Land is owned by individuals known as Tindanas who are generally distinct from the Chiefs or rulers of the people. The Tindana must be approached by any person wishing to farm on his land. The applicant brings a propitiatory gift of grain, fowls, hoes, cash, etc., according to his position. Where the population is dense and in consequence the demand for land acute, the Tindana at times requires a gift of considerable value before he will allocate land to a farmer. After harvesting a bountiful crop the farmer may present the Tindana with a quantity of grain or peto, a fermented drink made from guinea corn, as thanks-giving for a good crop, but this although almost universal is not compulsory. If the crop has been a failure, a similar gift may be made, when the Tindana will either allocate a new piece of land or advise as to what crop should be tried on the same plot the following year. In the case of a party who wishes to settle and build on the land, a gift of fowls or guinea fowls is held necessary for the purpose of making a sacrifice to the land ; the applicant is conducted to the Chief by the Tindana and the compact settled by the drinking of peto. The Tindana may give part of his present to the Chief or may simply notify him that he has received a present. At times the Chief will receive a separate gift. These preliminaries having been completed, the land is held by the farmer so long as he keeps it in cultivation. After an interval the Tindana may call for a tribute from all the farmers on his land. These tributes are pooled and sold, and a sheep or bull bought for the purpose of making a communal sacrifice. On the two last points the writers differ from Cardinall (2) who states that " Once the land is given, it is given in perpetuity. The only remnant of the Tindana's former ownership is a tithe paid annually, a basket of guinea corn or millet which the farmer renders to the Tindana. The total of these tithes is exchanged for a sheep or a cow, and this is sacrificed at the Tengani to the Earth God, the whole community attending. "

Absence of Villages.

Compact villages do not occur in these districts, the family, sometimes running into several generations, lives in flat-roofed round houses within a common wall, and is a unit by itself. The compounds, in the nature of primitive fortresses, stand from fifty yards to a quarter of a mile apart and are surrounded by the farm lands of the inhabitants. In addition to the lands around the compound, many people, especially those in the less densely-populated parts, work farms some distance from their homes. The systems of agriculture practised on the compound and on the " bush " farms are distinct.

FARMING PRACTICE.

The crops cultivated by the people are exclusively annuals of which the cereals, millet and guinea corn, predominate. The system of growing these is unique in this Colony in that they are grown, year after year, on the land immediately surrounding the compound. A small portion of the land is manured each year with household refuse and animal manure, and a small portion is periodically fallowed. In the " bush " farms rudimentary rotation combined with shifting cultivation is employed. Cereals are grown continuously until the yield deteriorates markedly, then groundnuts and late millet are intercropped, or groundnuts planted alone, until yields dissatisfy the farmer, who will then remove to a new area leaving the old farm to fallow for two three years.

The basic system of farming consists in taking two cereal crops in one year from the same area. This is done by interplanting early millet with late millet or guinea corn, or sometimes with both. Neri, cowpeas, soup plants and fibre plants are invariably found within the cereal plot, the fibre plants being used to demarcate the farm boundaries. A small area of maize is grown on the heavily-manured land immediately adjoining the compound, while rice, the least common of the cereals, is found only in small patches. Second in importance to the cereal crop as a whole is the groundnut. It is widely grown interplanted with bambarra nuts or with late millet on unmanured land some distance from the compound. Bambarra nuts are grown in pure stands as is the geocarpa nut. Each farmer grows a few beds of *Coleus* and *Ipomœa* potatoes on the wettest land available. Yams are little grown except in the south ; in a few places elsewhere odd plots are to be found. Most adults smoke, and sufficient tobacco is produced to satisfy their requirements ; this is grown on carefully prepared manured land. Pepper plants are found under tree shade near the compounds.

Crops Grown.

The cultivated crops, of which the most important are cereals are listed in Appendix A. Common, botanical, Hausa, Grunshi, and Frafra names are given. The crops are similar to those grown throughout the grass savannah country, but the cultivation of root

crops is more limited than is usual. A certain amount of food is obtained from the following trees which receive no cultivation *Adansonia digitata, Butyrospermum Parkii, Parkia filicoidea.*

Varieties.

Several varieties of millet and guinea corn are recognised by the natives, as are bean and potato varieties. Information on varietal differences and their value is being obtained by the Botanist.

Implements Used.

All cultivation is done by hand ; the only implements used are a small adze and a hoe. The adze is made of soft, native-tempered iron, the head being about four and one-half inches long by two inches broad. It is set at an angle of 45 degrees to a shaft about two feet long. This implement is used for clearing bush and for cutting cereal stalks at the base. Hoe patterns vary, but in all cases the head is set at such an acute angle to the short shaft that, when the worker is bending to his task, the soil is merely scraped to a depth of from two to four inches. Deep cultivation is impossible with such implements.

Manuring.

On the compound-farm a small portion of the area is treated annually with household refuse and animal manure, supplies of which are occasionally purchased for this purpose. On the bush-farms a limited use is made of wood ash. At times, industrious farmers manure growing crops with a mixture of cow manure and water which is sprinkled on the land by hand from a calabash .

Preparation of the Land.

New Farms. The land is stumped, cleared, and roughly hoed in the dry season, and is finally levelled, hoed, and the debris burned immediately before the early rains set in .

Previously Cropped Land. All crops are off the land by the end of November and the land lies fallow for several months. Previous to the rains the land is hoed for the early crops. Normally the cereals are grown on the flat, but rice is frequently found on beds raised to a height of 12 to 18 inches. As stated previously, the construction of the hoe does not permit of deep cultivation ; therefore if the yield of cereals on a continuously cropped plot is diminishing, ridging is performed as an alternative to deep hoeing, and the cereals are grown on ridges either alone or interplanted with groundnuts. Groundnuts in pure stands are generally sown on the flat, whereas *Bambarra* and *Geocarpa* beans are grown on raised beds, as are *Coleus* and *Ipomœa* potatoes. Tobacco is grown on carefully prepared beds which are frequently situated under tree shade.

Planting.

When the land has been prepared the early millet crop is usually sown first. The men, using a stick about five feet long, make holes

in the ground into which seed is dropped by other members of the family; the seed is then covered by treading. When the millet is above ground, planting holes are again made midway between the young plants. The sower carrying a small calabash containing grains of guinea corn or late millet mixed with a few beans and neri seeds, sows the cereals as above, and at intervals drops a bean of neri seed into the same hole as the grain. In the case of the root crops, the sprouted tubers of the *Coleus* potato are planted, whereas the vines of *Ipomœa* potato are used.

Planting distances are given in Appendix B, and the time or planting in Appendix C. The cereals are not planted in rows, but the number of plants per unit area is remarkably constant. Appendix B gives the mean of several counts, but individual variation in sample plots has been small. The spacing of interplanted minor crops varies with the farmer's requirements.

After Cultivation.

Hoeing is practised about two months after planting to keep down weeds; then, after the harvesting of the early millet crop, the guinea corn and late millet are weeded and slightly earthed up to give a certain measure of support to the long stems. Other crops are given one or two weedings.

Harvesting Cereals.

Early millet is reaped from mid-July to mid-August according to season and locality. The stalks are cut off at ground level by men using their native adzes or worn-out hoes. Women and children cut off the heads and convey them to their compounds for drying on the flat-roofed houses. In many cases a selection process is carried out at this stage, the best heads being stored separately for seed. The remaining heads are graded into two sorts; those of second grade, consisting of poor and damaged heads, are set aside for immediate consumption, whereas the first grade heads are stored in bulk. The stalks are removed from the land and some are burned to obtain ash, the soluble part of which is used in conjunction with powdered tobacco to make a chewing mixture. The early millet crop, when ripe, is from five to six feet high, while at this stage interplanted late cereals are some two feet in height. As will be seen from the spacing Table, Appendix C, the average distance between cereal is one and a half feet, the early and late crops being planted alternately. With the removal of the early crop, the late cereals stand some three feet apart. These are reaped in a similar manner to early millet. The stalks of guinea corn are used for fuel or for roofing houses, but most of the stalks of late millet are left on the land to provide humus.

Harvesting of Non-Cereals.

The non-cereal annual crops are simply hoed up and conveyed to the compound for storage.

Transplanting.

When the early millet crop has been reaped there is a short lull in farming operations before the second weeding of the cereals begins. Some farmers take advantage of this time to prepare a small patch of land into which they transplant late millet. Single plants, with the tops cut off the leaves, are transferred to the newly-prepared land and planted three feet apart. This is a precarious crop, which in the absence of late rains, often fails to mature.

YIELDS.

From measurements of sample plots of early millet interplanted with late cereals, on land round a compound, the yield of the former was found to be eleven cwts. per acre of dried grain. The percentage of dried grain to wet (newly-reaped) heads was 55.8, and the percentage of dried grain to dried head was 82.7. On a similar farm in a sparsely-populated and less intensively-worked area, a sample plot, apparently under average in productivity, yielded 600 lbs. of grain per acre. The yield of the late cereals millet and guinea corn were at the rate of 5. 1 cwts. and 5. 7 cwts. per acre from land which had carried an early grain crop in the same year. The total grain yield from two crops grown on the same plot in one season was 16. 1 cwts. made up of 11 cwts. of early millet and 5. 1 cwts of late millet, or 16. 7 cwts made up of 5. 7 cwts of guinea corn and 11 cwts of early millet. The yields of other crops were as follows :—

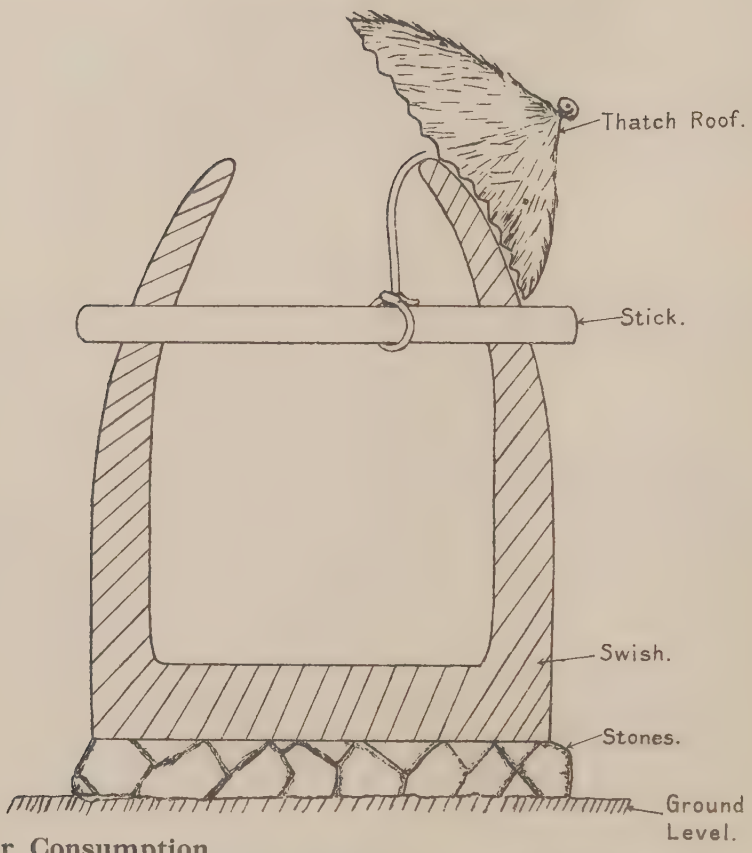
Groundnuts 630 lbs per acre (unshelled).

Coleus potatoes 3,050 lbs per acre.

STORAGE OF CEREALS.

The granaries are made of swish mixed with the mucilaginous liquor obtained by steeping the pods of *dawadawa—Parkia filicoidea* in hot water ; the mixture sets like cement. The base of the structure is generally set upon a stone foundation covered with a thick layer of swish. Termites are excluded by the use of a protective layer of ash. That obtained by burning mahogany (*Khaya senegalensis*) and an undetermined species of *Gramineæ* is specially favoured for this purpose. The shape of the store, which has no opening other than at the top, is as shown in the sketch below. The roof consists of a conical thatched head, tied down, when necessary, by a rope attached to a cross-beam, or weighted down by stones. The walls vary from four to eight inches in thickness. The large granaries vary in capacity from fifty to one hundred and fifty cubic feet and the small granaries from twelve to twenty cubic feet.

Grain Store.



For Consumption.

Such granaries are invariably used for the storage of cereals in the head. Shea nuts sometimes occupy the smaller type of store.

For Seed.

In the case of the early millet crop, the selected seed for the following year's sowing is threshed, mixed with the ash of mahogany and a species of grass to assist in combating weevil attack, and stored in earthenware pots. These are commonly sealed with swish which is broken from time to time to allow the grain to be examined.

As the early millet crop is stored for some eight months such precautions are necessary ; the seed is liable to lose its germinating power through insect damage if stored in bulk. In the case of the guinea corn and late millet crops no special precautions are taken with the seed. Rice is cut, threshed, and stored in earthenware pots.

Storage of Leguminous Food.

Unshelled groundnuts are kept in the smaller type of cereal store or in large baskets. Shelled nuts are kept in earthenware pots as are *Bambarra* and *Geocarpa* nuts.

Storage of Root Crops.

The root crops, *Coleus* and *Ipomœa* potatoes, are stored by one of two methods. They may be peeled, sliced and partially boiled after which they are dried and put in pots or the fresh tubers may buried in a pit in the earth. The latter method is adopted if tubers are being kept for seed.

Allowance of Grain storage per Head.

From a census of 170 compounds in a densely populated area (Appendix D) together with the measurement of grain stores in each compound, it was found that provision had been made for the storage of about 250 lbs. of dry grain per head to outlast the period from the harvesting of the main, to the reaping of the early, millet crop of the following year, a period of eight to nine months. This figure was obtained by measurement of bushels of unthreshed millet and, as the bushel weight varies considerably with density of packing, etc., it can only be regarded as approximate.

AREA CULTIVATED PER HEAD OF POPULATION.

From measurements of farms in the densely populated parts, the area of land cultivated per head of population is approximately 0.4 acre, while in the sparsely populated regions the area cultivated is approximately 0.8 acre per head. This may be explained by the fact that in the thinly populated areas a more extensive system of farming is practised. In addition, produce from such localities is conveyed to the more congested areas for sale. In dealing with the districts as a whole the figure 0.6 acre has been taken as the average area cultivated per annum per head of population.

PROPORTION OF CEREALS TO NON-CEREALS.

From the above measurements the following approximate figures for the relative proportion of cereal to non-cereal crops in an average year were obtained :—

Cereals	...	75 per cent.
Non-cereals	...	25 per cent.

In arriving at these figures due consideration has been given to the fact that in the majority of cases two crops are obtained from the same piece of land in one year ; these are commonly early millet and a late cereal. The major crops planted alone are usually

groundnuts or late millet ; guinea corn is infrequently planted alone The system adopted was somewhat empirical in that plots that had borne one crop in a season were taken as one unit, whereas those that had borne two crops were considered as two units. It is recognised that this is somewhat arbitrary, and that one would naturally expect land that is bearing a pure stand of groundnuts or of late millet to give a higher yield of the individual crops than the plot which is producing two crops in one season. At the same time it must be remembered that the two-crop system is employed near the compound where the land is in good heart as a result of manuring, whereas that under single crops is generally at some distance from the compound and does not receive animal manure or household refuse.

Increased Groundnut Areas in 1930.

During the present year it is probable that the acreage under groundnuts has been considerably increased owing to the fear of locust depredations.

AREA UNDER CROP.

The total population, area, and density of population per square mile of the districts of Navrongo and Zuarungu is tabulated below.

District.	Population	Area.	Density per sq. mile.
Navrongo	100,000	1,560	64.
Zuarungu	120,000	780.	154.

The figure of 100,000 which the writers have taken tentatively as the population of Navrongo is based on the following :—

(a) The population of 82,122 obtained from the 1921 census records in which certain villages did not appear.

(b) Natural increase.

(c) An allowance for immigration from the French Haute Volta region.

The population of 120,000 for the Zuarungu District is based on similar considerations, the figures at the 1921 census having been 97,921. It is known that several entirely new villages have been established since 1921 as a result of immigration from French Territory. The areas recorded have been computed roughly by the writers, as the district boundaries have been altered since the 1921 census was taken. Using the figure of 0.6 acre per head, the area under crop in one year is as follows :—

$$\text{Navrongo } \frac{100{,}000 \times 0.6}{640} \text{ sq. miles} = 93.75 \text{ sq. miles}$$

$$\text{Zuarungu } \frac{120{,}000 \times 0.6}{640} \text{ sq. miles} = 112.5 \text{ sq. miles.}$$

These figures represent 6 per cent and 14 per cent of the total area of these districts in the order named. The figures make no allowance for land lying fallow, nor do they make allowance for the food materials obtained from uncultivated trees. The area of fallow land is not less than one-third of the cropped area.

STOCK-REARING.

Horses, donkeys, cattle, sheep and goats are found throughout the districts, but mixed farming can hardly be said to exist. Live stock is grazed in common over all available land not under crop. Horses are owned by men of wealth, and to a lesser extent the same may be said of donkeys and cattle. Sheep and goats are common. Pigs are seldom seen because it is not customary to enclose animals, and pigs have an unfortunate habit of uprooting growing crops. Sheep and goats are herded by the youths of the family or are tethered while grazing. Cattle may be herded by the family of the owner or by a hired Fulani man. The Veterinary Department is raising the standard of cattle by eliminating scrub bulls and by supplying sires of good conformation. Such aspects of mixed farming as cattle-feeding and housing, storage of manure, and improvement of pastures have received no attention. The food crop areas are small, no animals are employed in farming operations, all cultivations being done by hand. In the dry season the bulk of the grazing land is burned up and the live stock moved to wet places where grass persists. Irrigation, for the purpose of growing additional food crops for the people or of augmenting the supplies of cattle fodder, is never practised, and in most cases would be impracticable on a small scale.

EXPORTS AND IMPORTS.

Exports are at present limited to sheep, a few cattle, a small supply of shea butter, some groundnuts, and fowls. Sheep are commonly bought by lorry-drivers and conveyed into Ashanti. The principal imports are rock salt and cola nuts together with cotton cloth either native or factory. Cotton is seldom seen in this part of the country, weaving is not practised, and little or no clothing is worn except in the large villages.

LOCAL CONGESTION.

The density of population per square mile in these districts is high for self-supporting farming areas in this country, but the figures for average density bear no relations to the actual distribution of the people. There is marked congestion in certain areas whilst others are sparsely populated or almost entirely uninhabited.

Reasons for Congestion.

The reason for such extreme congestion is somewhat obscure. It may be due to a combination of such factors as :—

(a) Proximity to the ancient trade and cattle routes.

(b) The presence of good supplies of drinking water during the dry season.

(c) Settling on land of proved fertility.

(d) The possibility that in the not very remote slave-raiding days, heads of compounds settled close to one another for the purpose of mutual defence in time of need, but remained far enough apart to maintain their compounds as practically independent units in times of peace.

UNDER-POPULATED REGIONS.

Portions of the sparsely-populated regions are definitely unsuited to settlement on account of annual flooding or low fertility It is highly probable that scarcity of water at certain periods of the year is a limiting factor in the settlement of some regions, but so far as can be judged by the writers without actual crop trials, considerable areas are suited for periodic cultivation, if not for settling.

Effects of Congestion.

Pressure of population has brought into being the system of continuous cropping carried out at present in the closely-farmed parts of the districts. This system has evolved naturally as a result of ages of experience and is reasonably effective. Further studies of the indigenous agriculture, together with trials based on native practice, require to be conducted before alterations likely to prove of material benefit to the people can be recommended.

CONCLUSION.

Farming, which is intimately bound up with the religious beliefs of the people, is the only work of the bulk of the population during the rainy season. So long as the people are merely self-supporting there will be less incentive to improved farming methods than would be the case were an export crop grown or a flourishing live stock trade established and the demands of the people rendered more diverse. The only indigenous crop suitable for export would appear to be the groundnut, but the expense of motor transport to Kumasi, a journey of over 350 miles, would render the industry unprofitable. The extraction of groundnut oil from the nuts in the north would reduce transport charges however, and in this connection the result of trials at Tamale will be awaited with interest.

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1. Shantz and Marbut.—Vegetation and Soils of Africa.

2, Cardinall.—Natives of the Northern Territories of the Gold Coast, p. 60 para. 2.

APPENDIX A.

List of more Common Crops Grown in the Navrongo and Zuarungu Districts.

Common Name.	Botanical Name.	Hausa Name.	Grunshie Name.	Frafra Name.
Millet (early)	Pennisetum typhoideum	Gero	Chara	Nara
Millet (late)	Pennisetum spicatum (var)	Maiwa	Mupona	Zia
Guinea corn	Sorghum vulgare	Dawa	Yra	Kyi
Groundnut	Arachis hypogea	Geda (Gujia)	Sunige	Supam
Bambarra Bean	Voandzeia subterranea	Kwaruru	Sia	Suma
Geocarpa Groundnut	Kerstingiella geocarpa	Kwaruru	Zerinde	Sumpui
Fura-fura potato	Coleus dysentericus	Tumuku	Yeya or Yiah	Persa
Sweet potato	Ipomoea batatas	Dankali	Nenuri	Nubienko
Beans (Cowpeas)	Vigna sinensis	Wake	Saaw	Tua
Maize	Zea Mays	Masara	Kamana	Karuwana
Rice	Oryza sativa	Shinkafa	Mumuna	Muio
Okro	Hibiscus esculentus	Kubewa	Pueleh	Marma
Pumpkin	Cucurbita Pepo	Kabewa	Gango	Yogon
Neri	Cucumis Melo	Gurji	Yergani	Sarma
Peppers	Capsicum frutescens	Barkono (Tankwa)	Nyamedueh	Na-su-hi
Yam	Dioscorea sativa	Doya (dundu)	Pia	Nuyia
Tobacco	Nicotiana Tabacum	Taba	Nowoli	Taba
Soup plant	Sesamum sp (?)		Soto	Saleem
Soup plant			Nagani	Nangina
Fibre plant	Hibiscus cannabinus	Rama	Kanzaka	Berice
Fibre plant	Hibiscus sabdariffa	Sure	Vio	Bito
Calabash	Lagenaria vulgaris	Duma (etc.)	Zunga	Tungu
	2. Uncultivated Trees.			
Shea	Butyrospermum Parkii	Kadanya	Songo	Tama
Baobab	Adansonia digitata	Kuka	Tieu	Twega
African locust-bean tree. (Dawadawa).	Parkia filicoidea	Dorowa	Suuwu	Dory.

APPENDIX B.

Spacing Table.

Crop.	Plant per acre in pure stands.			Interplanted with.	
	No. per acre.	Mean distance apart.		Names.	No. per acre.
A. Millet (early)	5,000	3′ x 3′	4,800–5,200	Band of C. J. K. L.	5,000
B. Guinea Corn	5,000	3′ x 3′	4,800–5,200	A and J. K. and L.	5,000*
C. Millet (late)	5,000	3′ x 3′	4,800–5,200	A and J. K. and L.	5,000*
D. Maize	8,000	2′ x 4″	7,000–9,000	Always pure stand	——
E. Rice	18,000	1′ x 6″	17,000–19,000	C.	9,000—1,200
F. Groundnuts	130,000	6½″	95,000–175,000	C.	4,350
G. Bambarra Beans ...	100,000	7″	——	Alone	——
H. Potatoes	95,000	8″	——	Alone	——
I. Peppers	12,000	2″	——	Alone	
J. Herbs and Fibres ...	Farm boundaries 1′x1′		——	Boundaries	
K. Cowpeas	Do not occur in pure stands.		——	A and, or B.C.J. & L.	150–500
L. Neri	Do not occur in pure stands.		——	A and, or B.C.J. & K	150–500

*Sometimes guinea corn and late millet are a mixed crop with early millet, when the total stands of B. and C. agregate to 5,000, the proportions varying.

APPENDIX C.

Table of Times of Planting and Harvesting.

Crop.	Time Planted.	Time Harvested.
Millet (early)	April—May	July—August
Millet (late)	May—June	October
Guinea Corn	May—June	September—October
Groundnuts	May—June	October
Maize	April—May	August
Fura-Fura Potato ...	June—July	September—October
Sweet Potato	June—July	September—October
Bambara Beans	June—July	October—November
Geocarpa Groundnuts ...	June—July	October—November
Cowpeas	April—May	October
Rice	May	November—December
Herbs	May—June	Through the season
Fibres	April—May	Through the season
Yams	January—February	Early yams in August Late yams in Nov-Dec.
Tobacco	August—September ...	During the dry season.

APPENDIX D.

Area Cultivated per head in Densely-Populated Region.

	No. of compounds.	No. of adults.	No. of children.	Total population.	Mean area in acre cultivated per head around compound.	Additional area cultivated per head.	Total area cultivated per head.
A.	170	1,469	966	2,435	0.26	0.09	.37
B.	6	40	21	61	—	—	.42
Total ...	176	1,509	987	2,496	—	—	—

Mean population of compound.
A = 14.9
B = 10.2
Mean area cultivated per compound A = 5.51 acres.
Mean area cultivated per compound B = 4.28 acres.

Mean area used in report for cultivation per head in densely-populated regions = 0.4 acre.

PAPER No. XXVIII.

CASSAVA MOSAIC.

By H. A. DADE.

Mosaic is a virus disease of *Manihot* which, although better known in other parts of West Africa, has not until recently attracted attention in the Gold Coast. In 1927 an examination of specimens from Obokapi revealed a very slight chlorotic spotting of the leaves, but the plants were not apparently affected. Local farmers have since stated that the disease was seen, in a mild form, in 1926, at Aburi. No previous record is known, and until 1929 occasional searches for the disease in several parts of the country met with no results. In 1929 and 1930, however, mosaic began to appear quite commonly, at least in some districts, and in a form sufficiently severe to be of marked economic importance.

There is no doubt that in a short time the disease will have spread throughout the Gold Coast, and, as cassava is one of the staple native food crops, the outlook is a serious one.

The disease has typical and well-marked mosaic characteristics. The leaves of the host plant are blotched with irregular light green patches and reticulations, and distortion occurs to a greater or less extent owing to the abortion of the laminæ in the chlorotic areas. In severe attacks the plants are so greatly stunted, and leaf distortion so alters their appearance, that they are conspicuous from some distance. The crop is reduced through interference with assimilation, and such tubers as form are unfit for food.

Virus diseases are usually transmitted from plant to plant by insects. In the present case the only insect which commonly frequents cassava is, according to the Entomologist, an Aleurodid fly, which may be the vector. Up to the present no critical investigations on transmission have been attempted the necessary insect-proof houses not being available. In present conditions of native cultivation, however, it is extremely improbable that control could be directed towards elimination of either the vector or the virus, and some other method must be sought.

There are a large number of local varieties of cassava in native cultivation, all apparently of the species *Manihot apii*. (*M. utilissima* does not seem to be represented). Each is recognised by certain morphological characteristics, and evidently a great deal of natural hybridisation has occurred since the introduction of the crop to

West Africa. These varieties are further distinguished by differences in the flavour of the cooked tubers and some are esteemed above others. In most of them the crop is ready for lifting about a year after the cuttings are planted, but in two varieties which are known, this period is extended to two or three years. The existence of these numerous varieties suggested trials of comparative susceptibility, with the object of finding a resistant or immune form. A collection of known varieties was therefore begun, and owing to the kind assistance of Messrs. A. S. Thomas, H. K. Hewison and J. J. Obeng, the following were obtained :—

Twi nomenclature.	Ewe nomenclature.
Bankye nkani	*Agbeli kani I.*
Bankye Culabar I	*Agbeli kani II.*
Bankye Calabar II	*Agbeli kani III.*
Bankye Congo	*Agbeli Calabar II.*
Bankye prampro	*Agbeli Congo.*
Bankye asonkofi	*Agbeli prampro.*
Bankye fitaa	*Agbeli " ordinary "*
Bankye ntomo	*Agbeli tomo*
Bankye pa	*Agbeli batracher*
Bankye Buadupa	*Agbeli ?* (*unnamed*).
Bankye sareso	*Agbeli Tarquah*
Bankye futu	*Agbeli ngwa*
Bankye hene	*Agbeli Dahomey*
Bankye Bede Kofi	*Agbeli akwako.*
Bankye Odiawo	
Bankye paya	
Bankye manno	
Bankye yampon black.	

" *Agbeli ngwa* " or " *Bankye* rubber " was also grown. This is *Manihot Glaziovii—Ceara* rubber.

Most of these varieties were planted at Aburi, and some others and a few duplicates of the Aburi plantings were grown at Kpeve by Mr. Hewison, who kindly undertook to assist in this way. No attempts were made to inoculate artificially the plants, all of which were of apparently healthy origin, but those grown at Aburi were planted in close proximity to a badly infested field. At Kpeve the cuttings were put into ground on which cassava had not previously been grown.

At Aburi all except two varieties were soon infected, and the attack became severe, although susceptibility varied to some extent. *Ceara*, which very commonly grows wild, also became infected. Similar results were obtained at Kpeve, though the attack was not severe, probably because the plants were grown in better soil. At

the end of 13 months the resistant varieties were still free from infection, and appear to be immune. One of these, *Calabar II*, was grown both at Kpeve and Aburi, with identical results.The other, *Bankye sareso*, was grown only at Aburi.

Calabar II is a long period form—that is, the tubers become ready for lifting after two years, or slightly less in good soil. The tubers are of very good quality, and are much esteemed, but the length of time necessary for maturation prevents this variety from being cultivated to any great extent.

Bankye sareso is a short period form, the tubers being ready for lifting after about thirteen months. The tubers have a slightly bitter taste when uncooked. The cooked tubers occasionally cause gastric disturbances and this variety is therefore less popular than some other forms. It is however, very commonly grown on the coastal plains, where it seems to tolerate drier conditions than other varieties and also is not uncommonly grown in the forest area. The tubers contain much starch, for the extraction of which this variety is often employed.

We have then apparently two varieties to which we may turn if we are forced to abandon cultivation of the more susceptible forms. Both of them are not so suitable as the more commonly cultivated and more susceptible kinds. They do however provide material from which, by selection and crossing, an immune and hardy short-period form, with good food qualities, might be derived. It is proposed to direct future work towards this end.

It seems to be a suitable opportunity, while we are dealing with this problem, to make trials of first class varieties from other countries, as well as with local varieties which may not yet have a place in our collection.

(Interesting papers on this subject, have appeared recently in the " Revue de Botanique Appliquée et d'Agriculture Tropicale "—in Tome IX, by J. Dufrenoy, and Tome XI, by R. P. Joly. According to these writers an immune variety " Senegali " has replaced others in the Duala District, and another immune "bitter " variety has been similarly employed in Oubangui. The raising of crop from seed is advised, as producing more vigorous plants than are obtained by vegetative propagation, and systematic selection work has begun. Their observations indicate that the disease is not so virulent in plants on good or well-cultivated soil, a fact which can be confirmed from experience in the Gold Coast, and it would appear that the vigour of the host is in this, as in so many other diseases, a factor of first importance. In the Gold Coast, vegetation has been carried on for generations, and it is doubtful if crop has ever been deliberately raised from seed, though the many varieties which now exist have probably arisen from naturally sown seed. No doubt the older and more popular strains have lost vigour to a considerable extent).

PAPER No. XXIX.

MINOR RECORDS, DIVISION OF MYCOLOGY.

By H. A. DADE and J. WRIGHT.

Cases marked * are new records for the Gold Coast. Fungi marked † are newly named.

Case 463.† *Mucor buntingii.*

The new species of *Mucor* described by R. H. Bunting in "Fungi occurring in Cacao Beans," Paper VIII, Year-Book, 1928, has now been fully described by Lendner in "Deux Mucors Nouveaux," Bull. Soc. Bot. de Genève 2^{me} Ser., 1930, and has been named by him *Mucor buntingii.*

Case 506.* *Aspergillus flavus—A Fungous Disease of Locusts.*

Large numbers of dead locusts (*Locusta migratoria migratorioides*) were found by Cook, to bear fungus fructifications. Apparently healthy locusts which died during the night were examined the next morning. Mycelium was found inside the thorax and in the intestines, and masses of yellow conidial fructifications of an *Aspergillus* were bursting through the thin skin between the plates below the neck and at the articulations of the legs and wings with the thorax. There is, thus, no doubt that the fungus is parasitic, and not merely saprophytic on the dead insects.

Cultures of the fungus were sent to the Imperial Bureau of Mycology and to Mr. R. H. Bunting. In both cases the fungus has been diagnosed as a hitherto undescribed form of *Aspergillus flavus* which develops black sclerotia in culture.

Case 511.* *"Collar rot" of French Beans.*

French beans in a garden at Mampong-Akwapim were all killed off by a rotting of the tissues at ground level. A white mycelium on the stems and withered leaves proved to belong to the fungus *Corticium vagum.* The attack took place during a period of heavy rains.

Cases 512, 518.* *Sclerotium rolfsii.*

Jerusalem Artichoke and Scarlet Runner have now been added to the extensive list of local hosts of *Sclerotium rolfsii.*

Case 513. *Coconut Leaf Collapse.*

The leaf stalks collapse prematurely at their bases, and the leaves fall backward. The fruit bunches are thus deprived of support, and collapse in their turn. Isolated cases were seen at Labadi in 1928 (Case 472) and the disorder has reappeared in a more aggravated form in the Central Province. Leaf collapse occurs during the dry season, and the palms recover to some extent during the following rains. In both cases unsuitable water relation appears to be the cause of the trouble, with which no parasites are associated.

Case 516.* *Sorghum Blight.*

An outbreak of disease on guinea corn was reported from Kpeve Agricultural Station. The stems become discoloured—red and black—and collapse follows. The tissues are then found to be in a state of advanced decomposition. The rotting stalks are packed with a practically pure culture of bacteria. The disease is undoubtedly the " bacterial blight " known in other countries.

Control is obtained by burning the diseased plants, and by avoiding cultivation of sorghums in the same soil for some years.

Case 525.* *Eelworm damage to Tomatoes.*

Eelworms attacking the roots and causing the formation of nodules were found to be the cause of the dying off of tomato plants at Achimota. The attacked plants were also found to be slightly affected by the leaf mould *Cladosporium fulvum.*

Case 527.* *Leaf spot of Coco-yam.—Phyllosticta colocasiae.*

Phyllosticta colocasiae has been found causing the formation of spots on the leaves of the *Amankani* varieties of coco-yam. The spots are zonate and bear numerous black pycnidia of the fungus. In pot experiments at Aburi on the effect of potash on the development of the coco-yam these spots have appeared on the leaves of plants which were being subjected to a deficiency in potash.

Case 528. *Botryodiplodia theobromae on Yams* (*Dioscorea* sp.).

Yams in the storage house at Kpeve were found to be suffering from three distinct types of rot : (*a*) a wet rot in which the internal tissues resemble a soft, yellow mush, and a yellow, watery liquid exudes from the ruptured skin ; (*b*) a pinkish soft rot in which the internal tissues are slightly softened and there is a brownish pink discoloration ; (*c*) a dry brown rot in which a brown discoloration is followed by a dry crumbly disintegration of the internal tissues. Isolations were made in advance of the discoloured tissues and in each instance yielded the fungus *Botryodiplodia theobromae.* The difference in the

type of rot may be due to a difference in composition of the varieties of yam but is more probably due to the effect of secondary organisms. Attack takes place in the field and increases quickly in storage. The organism is a wound parasite, and damage to the tubers by rats and other animals and by careless hoeing is the probable cause. Control measures must take the form of a minimisation of this damage.

Case 529.* *Root-Rot of the Tree Tomato* (*Cyphomandra betacea*).

One of several tree tomatoes growing at Aburi was found to be attacked by root-rot. The disease travelled upwards in the stem causing a brown discoloration of the cortical tissues to which the fungus was confined. Several isolations were made from the tissues in advance of the discoloured zone and in each case yielded a phycomycetous fungus. Inoculated into cacao pods it produced the symptoms of "Black pod" disease. This fungus was sent to Prof. Ashby of the Imperial Mycological Institute who identified it as a strain of *Phytopthera parasitica*.

PAPER No. XXX.

A NOTE ON THE SAPROPHYTIC EXISTENCE IN NATURE OF *PHYTOPHTHORA PALMIVORA*, (BUTLER), THE CAUSAL ORGANISM OF "BLACK POD" DISEASE OF CACAO.

By J. WRIGHT.

The object of this small investigation was to test whether *Phytophthora palmivora*, known until recently as *P. Faberi*, was capable of living saprophytically over the dry season. Two possible media for the existence of this fungus are immediately suggested, viz., the soil and husk heaps.

De Bruyn (3), from a survey of phytopathological literature, concludes that most species of *Phytophthora* can develop as saprophytes in the soil. While this has been proved for many species, it has not been for others, among them *P. palmivora*. De Bruyn found that *P. syringae* and *P. erythroseptica* developed in unsterilised soil, and, after existing over five winter months, were able to produce infection. *P. syringae* was found to be able to infect lilac after growing for two years in sterilised bog soil. The fungi tested showed a preference for certain types of soil, e.g., *P. infestans* proved to have a preference for clay and bog soil. There are references in the literature to the continued existence in the soil of *P. fagi* after four years, *P. nicotianae* after three years and *P. cactorum* after two years. During the growing season in a cacao farm, millions and millions of conidia of this fungus must reach the soil where they may germinate and give rise to a mycelium. The fungus may exist as mycelium or may form chlamydospores—normally *P. palmivora* does not form oospores. The possibility that it does so in the soil, however, is not excluded for it has been shown to do so by Dade (2) when it is inoculated into cacao pods along with a strain of *P. palmivora* isolated from *Mimusops* sp.

METHOD.

The method adopted to test the possible existence of *P. palmivora* as a soil saprophyte was as follows: 80-100 grams of soil were placed in each of several small flasks. Half of the number were sterilised. A fresh isolation of the fungus was made and a two days old culture in 10ccs. of Czapek's solution was transferred to each of the flasks. The viability of the fungus was then tested after four months and again after six months.

Unfortunately a species of *Cephalosporium*, which is a continual nuisance in pure culture work at Aburi, had invaded the flasks containing the sterilised soil and on examination at the end of four months it was found to have produced a profuse ærial mycelium bearing spores.

It would be an arduous task to isolate *Phytophthora* from the soil by the usual means and therefore the following method was adopted: cacao pods were surface-sterilised and placed in roughly sterilised moist chambers. Two small wounds were made with a scalpel on each pod and a small quantity of the soil to be tested was placed on each wound. The appearance of the symptoms of "Black pod" marked the presence of the fungus in the soil. This happened in three cases. Eventually conidiophores and conidia of *P. palmivora* appeared on the surface of the pods and the isolation of the fungus in pure culture became an easy matter. Pods which were wounded only were used as controls. The results obtained are shown in Table I.

TABLE I.

	Time Interval.	No. of Inoculations.	No. of Infections.	Interval from inoculation to first appearance of infection.
Sterilised soil ...	4 months	14	1	9 days.
	6 months	6	Nil	
Unsterilised soil	4 months	14	2	8 days.
	6 months	6	Nil	
Controls. ...	4 months	4	Nil	
	6 months	4	Nil	

The invasion of the flasks containing the fungus in sterilised soil by the *Cephalosporium* sp. obviously upset the experiment but the fact that it effectively destroyed the *Phytophtora* supports the conclusion, which may be derived from the above table, that in the soil, *P. palmivora* of "Black pod" disease is incapable of competing with soil saprophytes and is gradually exterminated.

To test the continued existence of the fungus in diseased husks the following method was adopted. A similar quantity of unsterilised soil, as in the above experiment, was placed in each of several flasks. A ripe and diseased pod was husked and small portions of the husk which bore conidiophores of *P. palmivora* were placed in the soil in the various flasks. The presence of the fungus was tested after four months and after six months as in the above experiment. After six months the disintegrated pieces of the pod

were placed in contact with surface sterilised healthy pods and the disease was thus transmitted. The soil immediately surrounding the remains of the pieces of pod was also tested for the fungus in a similar manner and was found to contain *P. palmivora*. As before, pods which were wounded only were used as checks. The results of this experiment are shown in Table II.

TABLE II.

	Time Interval.	No. of Inoculations (wounded).	No. of Inoculations (contact).	No. of Infections.	Interval from inoculation to first appearance of infection.
Old pod ...	4 months	14	—	13	10 after two days. 3 after three days.
	6 months	6	—	6	All after two days.
	6 months	—	4	3	1 after seven days. 2 after eight days.
Soil adjacent to pod.	6 months	4	—	3	1 after two days. 2 after three days.
	6 months	—	4	4	All after three days.
Controls ...	4 months	4	—	Nil	
	6 months	4	—	Nil	

Dade (1) has found that in husk heaps after three or four months very few spores of *P. palmivora* occurred and, of these, the majority were empty or dead. Nevertheless, the results expressed in Table II show that the fungus has a continued existence in diseased husks and that even after six months it was still strongly virulent : and further that the soil immediately surrounding the husk also harboured the pathogen. In the mass of saprophytic organisms present in the disintegrated remains of the pieces of husk, it could not be ascertained in what form the fungus existed.

From observation and experiment, Dade (loc.cit.1) deduced that husk heaps were of little or no significance as regards carrying infection from one season to another and in Paper XIII has produced strong evidence to show that diseased pods, infected from cankered cushions, form the seat of infection of the crop. While it is not suggested that husk heaps are of any great importance they obviously are capable of harbouring the disease. Even if no conidia are produced which might be borne to the trees, the debris containing infection may be carried to the pods by tools, insects, snails, animals, wind, etc.

The results of Table I which show that *P. palmivora* cannot compete in the soil with the various saprophytes and is slowly killed out suggest that burying the husks would mitigate the possibilities of infection from husk heaps. Whether this is, economically, worth the trouble, is another matter.

SUMMARY.

1. In the soil, '*Phytophthora palmivora* has been found to be slowly exterminated by soil saprophytes.

2. It has been found to have a continued existence in diseased husks and was still strongly virulent after six months.

3. Possibilities of infection from husk heaps are stated and the probable mitigation of such infection by burying the husks is suggested.

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PAPER No. XXXI.

THE OCCURRENCE OF THE MIGRATORY LOCUST (*LOCUSTA MIGRATORIA MIGRATORIOIDES* IN THE GOLD COAST AND ITS DEPENDENCIES DURING 1930.

By G. S. COTTERELL.

INTRODUCTION.

This report is intended to be a continuation of that written by the late Mr. W. Cook, Entomologist, on the locust situation in 1929, which was published in the 1929 Year-Book of the Department of Agriculture (1). It is to be regretted that owing to the death of Mr. Cook much information that he possessed is not now available.

Information on the situation from January to September, 1930, has been obtained from notes written by Mr. Cook who was then engaged in carrying out locust investigational work, and also from reports received from various officers engaged on locust control. The present writer was absent from the Colony during this period and did not take up investigational work until his return in September. The earlier part of this paper must therefore be merely a record of events as they occurred and is possibly somewhat scanty in nature.

Much information has been obtained from members of the Political Service in the districts concerned who have to a large extent been dependent on information brought in by chiefs and local farmers. As far as the Northern Territories of the Colony are concerned no crops are on the ground for from five to six months in the year. Naturally the farmer's interest has a tendency to lapse during this period and much valuable information has therefore not been recorded. Details of the farming methods employed in the Navrongo and Zuarungu Districts of the Northern Territories, giving dates of planting and harvesting of the various crops, have been published by Muir and Williams (2).

The possibility of serious damage naturally depends on the proportion of cereal crops grown. Districts in the Gold Coast and its Dependencies where this is likely to occur are in the Keta–Ada District where maize production is the staple crop, supplemented to a large extent by cassava ; in the vicinity of Frankadua in the Volta River District ; and in the Northern Province of the Northern Territories where, with the exception of Wa, Lawra, Tumu and

Bole (Western Gonja) Districts, cereals form nearly the entire crop. A serious loss of the corn crop in the Northern Province would undoubtedly result in famine.

This report would be enhanced in value if accurate information was available from the neighbouring French Territories. A detailed report has been received on the situation in French Senegal but, as the report does not cover the French Haute-Volta and French Mandated Togoland, from whence the majority of swarms originated, and does not differentiate between the Desert Locust (*Schistocerca gregaria*) and the Migratory Locust, both of which are known to occur in French Senegal, the information contained is of little value to the Gold Coast. As pointed out by Uvarov (3) in the discussion on locusts during the Third Imperial Entomological Conference no one Entomologist employed by an individual Colony is in a position to study in full the general locust problem. Such a study must be put on an international basis. Such a study is being inaugurated under the auspices of the Committee on Locust Research who are commencing their studies on the Desert Locust.

The Migratory Locust first commenced its present activities in this country in November, 1928. The current year, 1931, is therefore the third year. The only known previous invasion lasted three years and it is presumed that 1931 will be the last year. General indications are that this will be so.

For a large amount of the information contained in this paper thanks are due to those members of the Department of Agriculture who were seconded for locust control and to members of the Political Service who have been responsible for reports on the location of adult swarms and hopper bands.

Thanks are also due to officers of the Royal West African Frontier Force who were seconded for locust control during the hopper infestation early in 1930.

GENERAL SITUATION AT THE END OF JANUARY, 1930.

Cook in his report (1) stated that at the time of writing, a few small flights were traversing the Salaga (Eastern Gonja) District in the Northern Territories in the neighbourhood of the River Volta as well as in the Gambaga and Zuarungu Districts of the Northern Province. In Southern Togoland and the Trans-Volta District of the Colony swarms were circling in the Dafo, Ve and Kpeve Districts and also in the Keta-Ada District.

OCCURRENCE OF ADULT SWARMS AND HOPPERS IN SOUTHERN TOGOLAND AND THE COLONY FROM FEBRUARY TO JUNE, 1930.

ADULT SWARMS.

In February those swarms circling in the Keta-Ada District appeared to desert that area entirely. Swarms were recorded as constantly passing over Dafo, Ve and Honuta Districts in a north-easterly direction towards French Territory.

A further heavy invasion from French Territory between Nyive and Djodje occurred on the 10th of March. These swarms were all sexually mature and circled around for some days in the cultivated district north of the Keta lagoon. Oviposition took place about the middle of the month at Djodje, Avenorpeme, Dabala, Adidome and Kpejeglo, and also along the River Volta between Adidome and Senchi. Oviposition areas were scattered owing to individuals of the same swarm reaching maturity at different periods. Sites chosen for oviposition were similar in all cases, the soft bare soil between clumps of burnt grass being chosen in every case.

Another large sexually mature swarm came from the north from the direction of the Afram plains about the middle of March. These oviposited in the bare plains in the neighbourhood of Kpong and Senchi. This swarm passed over Akuse and westwards along the coastal plain and was ultimately recorded as far west as Cape Coast District. Eggs were laid in scattered places all over the Akuse plains, to the north of Accra, and in the Cape Coast District.

HOPPER BANDS.

Hatching occurred from 10 to 15 days after oviposition, and, as parts of the same swarm reached sexual maturity at different periods, extended over a period of from three to four weeks. Therefore by the end of May hoppers of all ages were present in the affected areas.

DAMAGE TO CROPS.

The adults responsible for oviposition did little damage as very little corn had by that time been planted. Hatching, however, coincided with the planting of the maize crop and the later-hatched hoppers reached maturity when, late in April, corn had been planted on an extensive scale, particularly north of the Keta lagoon, and was at a stage where it formed an ideal form of food. Numerous farms were invaded and the crop destroyed. This necessitated extensive replanting, some of this second crop being also destroyed, and a considerable loss in the ultimate crop resulted. It was reported that on account of the presence of locusts, the local farmers planted much less corn than in normal years. Control measures were instituted by the Department of Agriculture. These measures consisted of the use of cloth barriers staked in the ground in the line of advance of a band of hoppers, coupled with the use of trenches. This method has been found impracticable. The ordinary trenching method was then employed and was partly successful although considerable difficulty was encountered in getting the local population to turn out unless the hoppers were in the actual process of invading their farms Supplies of poison had not then arrived and therefore it was not possible to employ this method which would appear the most suitable for this type of country.

Individuals that eventually reached the adult stage circled about until swarms large enough for migration were formed when they flew off in a north-easterly direction.

OCCURRENCE OF ADULT SWARMS AND HOPPERS IN THE NORTHERN TERRITORIES AND ASHANTI FROM FEBRUARY TO SEPTEMBER, 1930.

ADULT SWARMS.

During February and March small swarms were reported as circling around Yendi and Tamale and surrounding districts. Oviposition took place generally all over the Southern Province of the Northern Territories at the end of March. There is no record as to where these swarms came from but it is presumed that they came from the south-east having been circling for some months in the Krachi District, Afram plains and French Togoland.

HOPPER BANDS.

Hatching of hoppers occurred in Tamale and Salaga Districts and also to the south of Yendi early in April. Hatching was also reported at Bole in the west. Hatching commenced with the commencement of the early rains over the whole of the Southern Province. No hoppers were reported in the Northern Province until May when a heavy infestation occurred in Wa, Lawra and Tumu Districts.

Ashanti appears to have remained comparatively clear. An adult swarm passed over Kintampo early in April and hoppers were reported in the vicinity of Attabubu and Yeji shortly after. Little damage was done by hoppers but the swarm responsible for oviposition caused some damage to the young maize crop. By the end of May most of the hoppers in the vicinity of Salaga and Krachi had become adult and ultimately flew off in a north to north-easterly direction. Except for a few bands in the neighbourhood of Tamale, the Southern Province was practically free of hoppers by the end of May, the adults having flown off in a north-easterly direction. Again relatively little damage was caused by the hoppers.

Early in May further swarms flew over the Northern Province of the Northern Territories travelling from east to west. These swarms were distinct from those coming from the south and were sexually mature, the former consisting of young adults arising from hopper bands bred in Northern Ashanti and the Southern Province of the Northern Territories. During mid-May oviposition was general all over the Northern Province, being heaviest in Wa, Lawra and Tumu Districts and more scattered in Navrongo, Zuarungu and Mamprusi Districts where the limit of flight was apparently reached. Hoppers of all ages occurred in June and had become adult or had been destroyed by the end of June.

Control measures were instituted, officers from the Royal West African Frontier Force being seconded until it was possible to replace them by Agricultural Officers.

Surviving adults all took a northerly direction as soon as sufficiently large swarms had formed, or else joined up with immature swarms from the south, and were lost sight of over the French border. During July and most of August the whole of the Northern Territories was free from locusts with the exception of near Gambaga, and at Chana and Kologu in Navrongo District where a few small bands of hoppers were reported.

DAMAGE TO CROPS.

In the Northern Province no severe damage was done to crops by hoppers, as bands appeared chiefly in uncultivated country. The Tumu and Wa Districts are comparatively thinly populated and consequently the area under cultivation is small. A different state of affairs would have arisen if a heavy infestation had occurred on the eastern side at this time as this area is much more thickly populated and therefore heavily farmed. In addition, on the western side, cereal crops are largely supplemented by root crops whereas Navrongo, Zuarungu and Kusasi Districts are almost entirely dependent on cereals. Most of the damage was done by adult swarms responsible for the original egg-laying and by immature swarms from the south resulting from the hopper infestation there. Damage was particularly severe in the vicinity of Bole and Wa where a large amount of young corn was destroyed necessitating replanting. Farmers appeared to have suffered chiefly from the lack of seed-corn as a result of attack on late cereals in October and November, 1929.

The hopper outbreak in the Southern Province was also responsible for considerable damage to early cereals. In no district did a local famine result.

During August an immature swarm was reported in the Wa District. This swarm eventually left the Colony. Another immature swarm was reported in Zuarungu District going north into French Territory.

THE SEPTEMBER INVASION OF THE NORTHERN PROVINCE FROM FRENCH HAUTE VOLTA.

ADULT SWARMS.

Early in September numerous sexually mature swarms entered Kusasi District from French Haute Volta in the neighbourhood of Sapelliga. Some of these took a southerly course into Mamprusi District where they eventually split up. Others took a south-westerly course across Zuarungu and Navrongo Districts into Tumu, and later Wa District, where they also split up. Later in the month another mature swarm entered Tumu District from French Haute

Volta at Uru and immediately split up. Another sexually mature flight was reported as travelling in a south-westerly direction over Yendi and Mandated Territory about the middle of September. There is no doubt that these swarms had covered a considerable distance before invading the Gold Coast. The Northern Province of the Northern Territories formed the extreme limit of their flight and oviposition was confined to this Province.

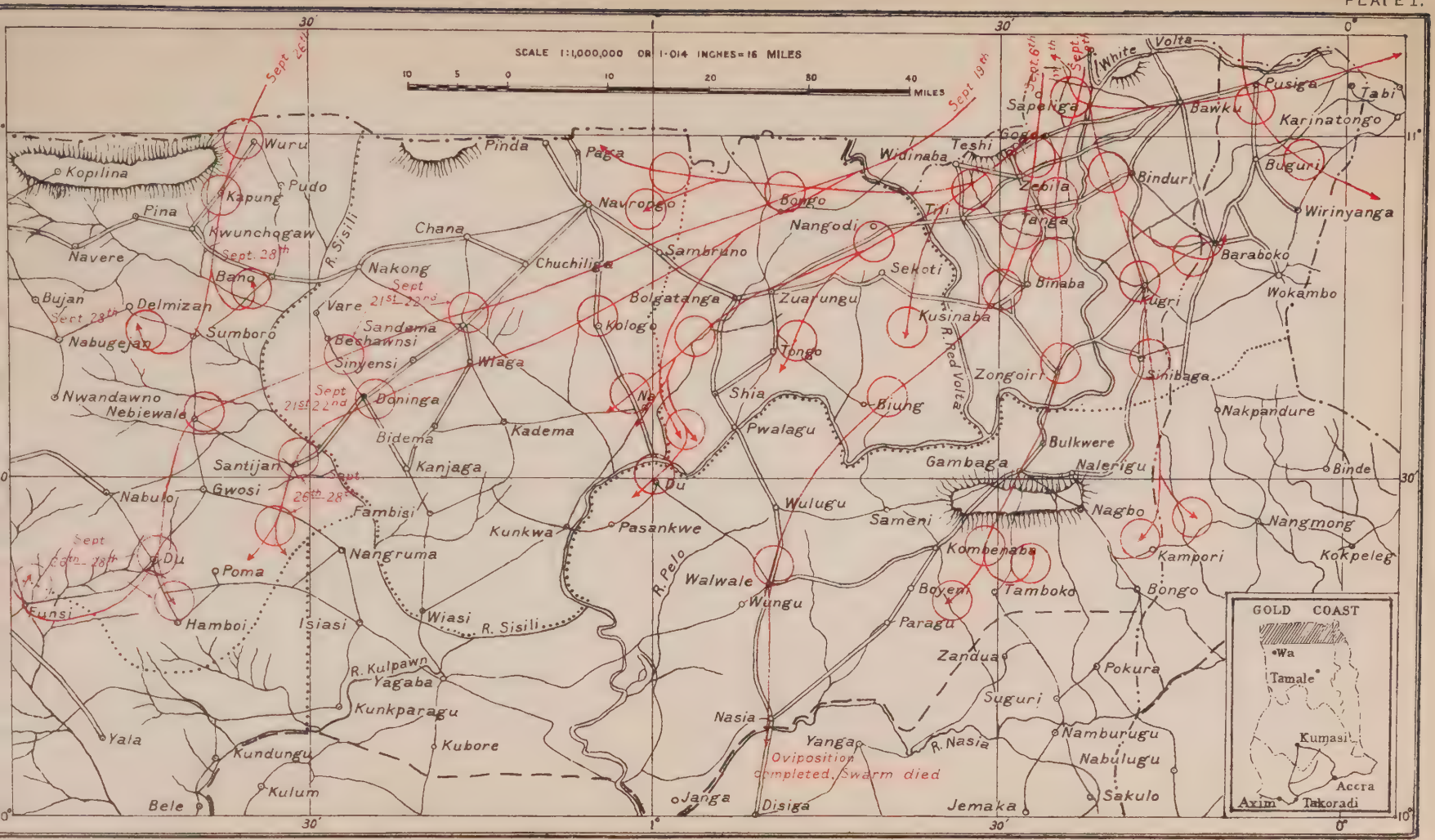
HOPPER BANDS.

Early in October hatching occurred on a heavy scale in Kusasi, Mamprusi, Zuarungu and Navrongo Districts, particularly in the two former, and later, on a smaller scale in Tumu District and in Wa District in the neighbourhood of Funsi. In all these districts, with the exception of Tumu and Wa, hatching occurred at the same time with the result that in October, hoppers of practically all the same age were present. In late October and early November large numbers of fourth and fifth instar hoppers invaded the eastern border of Kusasi and Mamprusi Districts from French Mandated Togoland north of Sansane-Mango. At this time Kusasi District and the eastern part of Mamprusi District were literally covered with hoppers. These bands were of approximately equal age and, as rains had by this time ceased and the country was rapidly drying up, they tended to congregate in the vicinity of water.

DAMAGE TO CROPS.

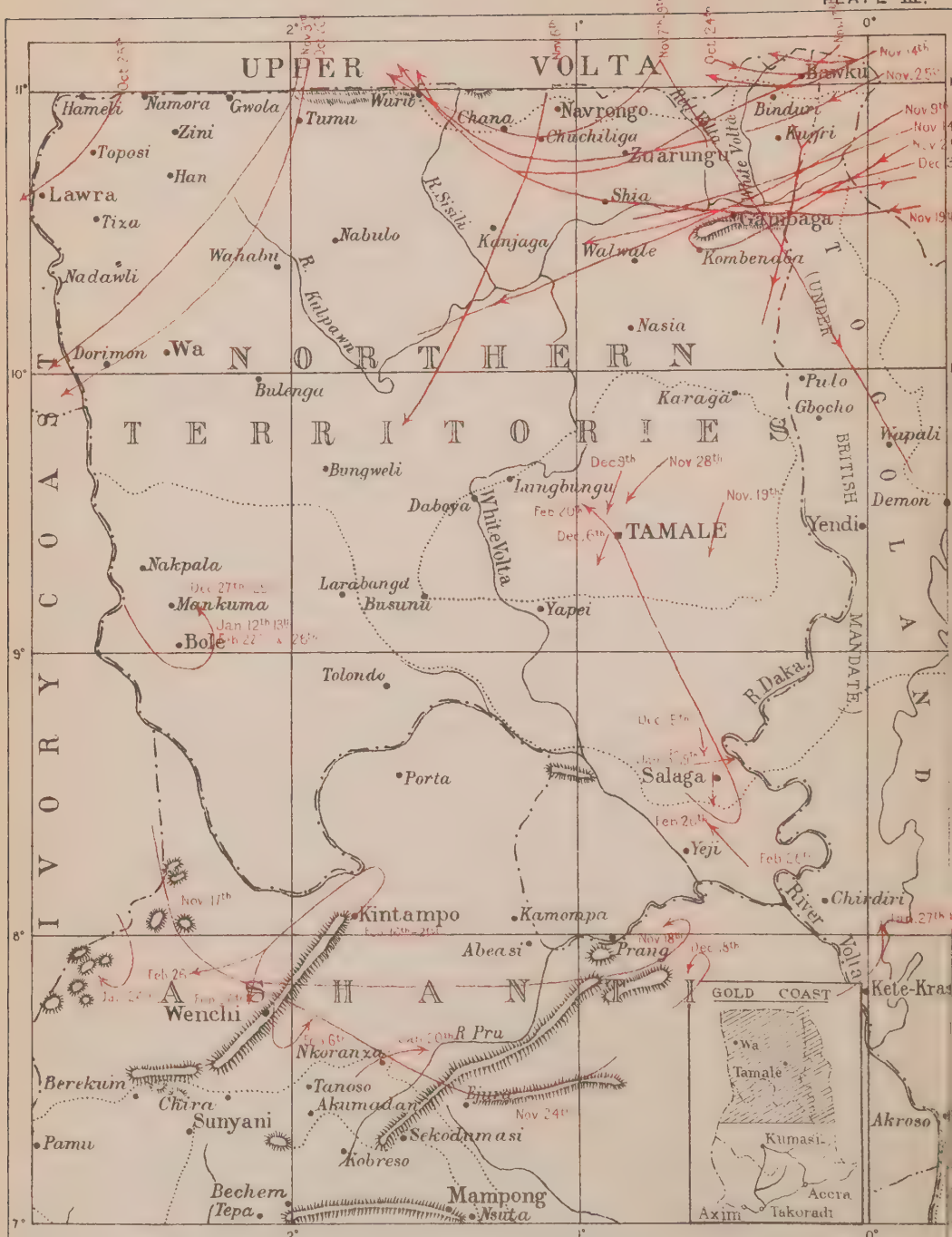
Localised damage to late millet and guinea-corn was caused by the original mature swarms but by early September these crops were sufficiently advanced not to be greatly attractive as food. Oviposition took place chiefly in bush particularly in the vicinity of swamps and subsequent feeding was almost entirely confined to grasses (*Pennisetum* spp.), a local fodder grass, grown in areas locally known as *Fadama* (Hausa), being mostly favoured. By the time hoppers had hatched, cereal crops were still less attractive as food. The only hopper damage observed was to late millet which had been planted considerably later than the normal time. Damage of this type occurred chiefly in the southern part of the Northern Province where cereals mature slightly later than in the north. A considerable amount of damage was undoubtedly avoided by the control measures adopted. In the neighbouring territory of French Haute Volta where no control measures were enforced until much too late, and where the hopper infestation was apparently much more severe, cereal crops were reported as being severely damaged.

If the September invasion had occurred a few weeks later there is no doubt that the position would have been serious, particularly in Kusasi District. The latter district grows considerably more cereals per head of population than the other districts invaded. Late in the dry season the people in the Zuarungu, and to a lesser



The September Invasion of the Northern Province of the Northern Territories from the French Upper Volta

PLATE III.



The October, November Invasion of the Northern Territories from Haute Volta and French Mandated Togoland by Immature Swarms, and their subsequent circling in Northern Ashanti

SCALE 1:2,750,000

MILES 20 10 0 20 40 60 80 MILES

SURVEY H.Q. ACCRA, 19

extent in the Navrongo Districts, purchased a considerable amount of corn from Kusasi farmers to supplement their own supplies. Kusasi forms a granary for the north-eastern districts of the Northern Province and serious damage there would have far reaching results.

Following the first reports of hatching in the eastern division of the Northern Province a scheme of hopper control was again organised. A supply of sodium arsenite was available in quantity and a large number of hopper bands were destroyed by the poison-bait method. Kusasi, Zuarungu and Navrongo Districts are thickly populated and heavily farmed. On account of the primitive type of inhabitant it was not in all cases considered wise to use poison-bait if the trenching method could be employed. It was found in most cases that the inhabitants could be relied upon to turn out *en masse* if the threat of the use of poison was employed, and successful drives into trenches made, when properly organised. In Mamprusi District, where the population is sparse, the poison-bait method was chiefly employed. As to whether the trenching or poisoning method is used depends largely on the nature of the soil. A large part of Zuarungu, Navrongo and Mamprusi Districts are totally unsuited for trenching.

Early in October an immature swarm was reported as originating in Kusasi District in the vicinity of Garu. This swarm passed south across Mamprusi District. It is possible that the swampy area in the vicinity of Garu forms an independent breeding ground. Three immature swarms were reported as crossing Lawra and Tumu Districts in a south-westerly direction in late October and early November. They passed out over the western frontier.

THE NOVEMBER–DECEMBER INVASION OF THE NORTHERN PROVINCE.

ADULT SWARMS.

Early in November, coinciding with the maturity of hoppers resulting from the September invasion, numerous immature swarms of varying sizes again invaded Kusasi, Zuarungu, Navrongo and Mamprusi Districts from French Haute Volta and French Mandated Togoland. These had bred not far across the border and were the progeny of the same group of swarms responsible for the September invasion. The majority took a westerly course with the prevailing wind across Kusasi, Zuarungu and Navrongo Districts, eventually turning north-west and re-entering French Territory in Tumu District. Adults arising from surviving hopper bands in the above districts joined up with these swarms as they passed over. At this time the harmattan first commenced and following the change in direction of wind a few swarms travelled south and invaded the Southern Province and also Krachi District. The harmattan ceased a few days later and again a westerly course was taken. Swarms were reported at intervals throughout November

and the early part of December as traversing the Northern Province in a westerly direction. Some swarms reached the limit of their flight in the neighbourhood of Bole, where they have been reported at intervals during December and January as circling in the vicinity whilst another passed south and invaded Northern Ashanti. Swarms that came south have since been circling in the Southern Province and at the time of writing (February, 1931) are not yet sexually mature. The immature swarms that entered the Northern Province in November and December caused no damage as the majority of crops had by that time been harvested.

ADULT SWARMS IN NORTHERN ASHANTI— NOVEMBER, 1930 TO FEBRUARY, 1931.

Northern Ashanti was invaded from the north about mid-November when an immature swarm was reported in Wenchi District. This swarm was later reported at Attabubu and Ejura where considerable damage to maize was done. It eventually split up and branches have continued to circle in Northern Ashanti chiefly in the vicinity of Wenchi, Tekiman and Kintampo without becoming sexually mature.

THE SECOND INVASION OF SOUTHERN TOGOLAND, TRANS-VOLTA DISTRICT AND EASTERN PROVINCE OF THE COLONY.

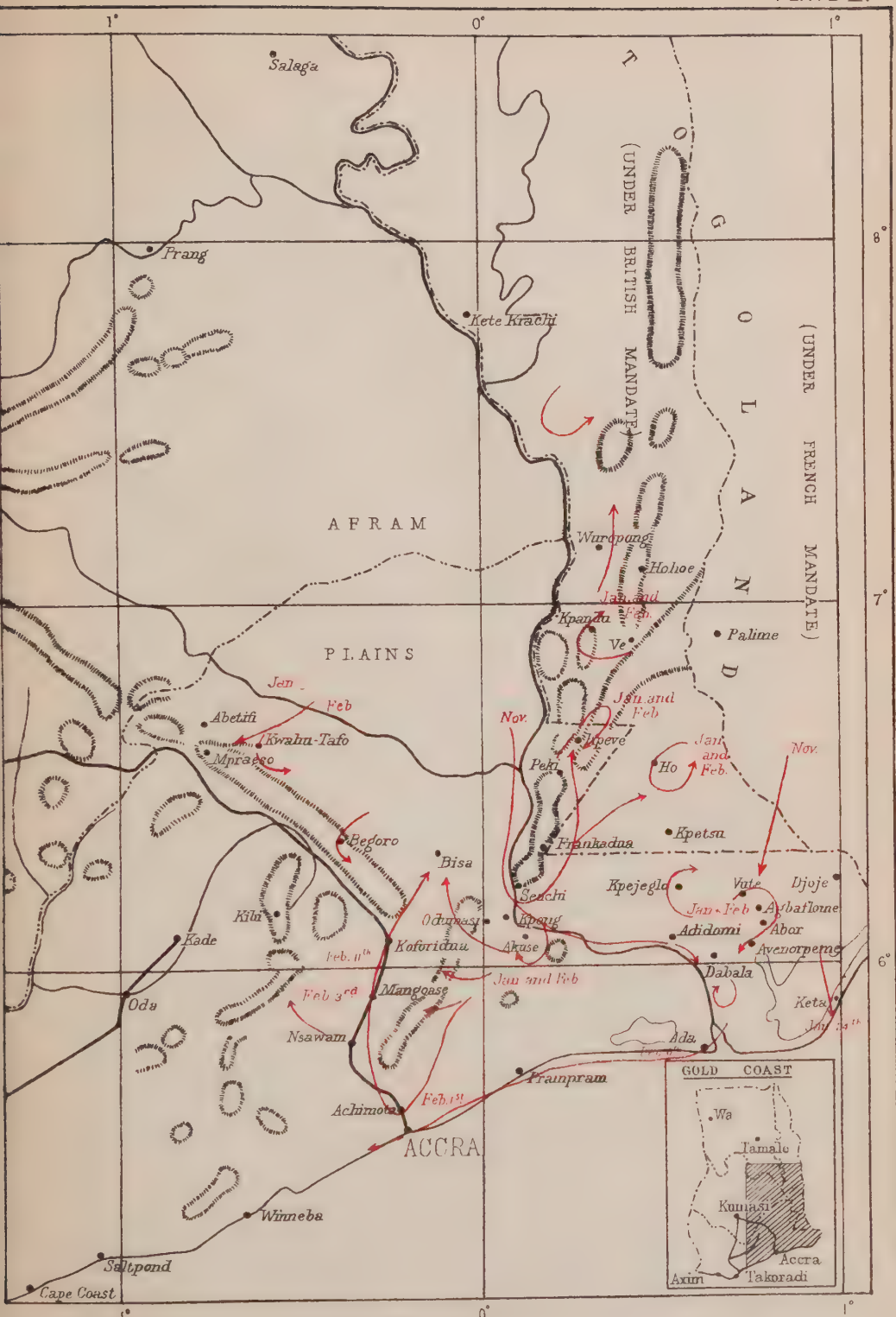
Akuse and Trans-Volta Districts were again invaded early in November when a large immature swarm entered from the direction of the Afram plains following the course of the River Volta as far as Dabala. This swarm split up and branches circled in the vicinity of Akuse whilst others passed north to Bisa, and to Frankadua, Peki and Ho, and circled those areas.

Another immature swarm entered British Togoland and the Trans-Volta District from French Togoland shortly after, between Kpetoe and Djodje, flying in a south-westerly direction. This swarm split up and circled the Ho District, the Keta District north of the lagoon, and the Ada District in the vicinity of Adidome and Dabala. Other swarms from the Afram plains, or branches of the previous swarms, invaded the Kpando, Hohoe and Ve Districts.

As the dry season advanced and the grass fires commenced, swarms in the open country south of Ho and in the vicinity of Frankadua tended still further to split up and to concentrate further south where grass was much more luxuriant owing to recent rains.

Late in January, a swarm circling north of the Keta lagoon appeared over Keta where a large number were blown out to sea. Following a reappearance of the harmattan early in February, another swarm passed south over Ada, then westwards over

PLATE II.



Immature Swarms in Southern Togoland and Eastern Province of the Colony - November to February 1931.

SURVEY H.Q. ACCRA, 1931

SCALE 1:2,000,000

MILES 10 5 0 10 20 30 40 50 MILES

Prampram to Accra, numbers being blown out to sea *en route* Branches circling in the vicinity of Akuse invaded the Akwapim Ridge at Mampong and Aburi, whilst others passed south-east towards Accra, over Achimota, Nsawam, Mangoase and Koforidua, following the railway clearing, finally disappearing in the direction of the Afram plains.

During December and January, the transitional forest area in the vicinity of Kwahu-Tafo in the Mpraeso District, and at Begero and Bosuso, was also invaded.

Cook (1) in his report on the 1929 invasion remarked on the fact that a number of the swarms in Southern Togoland during December and January, consisted of comparatively young adults indicating that independent breeding must have occurred—probably on the Afram plains. Following a report of independent breeding in December, 1930, in the cultivated area behind the Keta Lagoon the writer made an investigation and it was found that breeding had occurred on a small scale in November and December, in the vicinity of Agbosome and Wute behind the Keta lagoon. The hoppers did no damage as all crops had then been harvested. The resulting adults eventually joined up with older swarms then circling the district.

Again numerous small swarms were observed circling the Kpando, Ve and Hohoe Districts in February, 1931, consisting of individuals of mixed ages the majority having become adult during the last three weeks. Independent breeding must have taken place somewhere in the vicinity in November and December. This did not take place in any cultivated area and probably occurred on the Afram plains. It is more than likely that independent breeding took place on a much larger scale than was apparent. In addition to the Afram plains, independent breeding may also have occurred in the swamp areas alongside the River Volta between Akuse and Adidome without having been recorded.

PRESENT LOCATION OF SWARMS—FEBRUARY, 1931.

In the Colony and Southern Togoland the first heavy rains following the dry season occurred about mid-February. Subsequently all swarms tended to move north and a number has been reported as passing in a north-easterly direction into French Togoland, the transitional forest areas being completely deserted. At the end of February a swarm was reported at Tamale in the Northern Territories as travelling north-west.

CONTROL MEASURES.

INDIRECT CONTROL.

As previously stated in those districts in which cereals form the staple food crop, the danger from locust attack is far greater than where numerous other food crops are grown. The Northern Province of the Northern Territories, particularly the eastern

districts, and to a much smaller extent, the corn-growing area behind the Keta lagoon and parts of the Akuse District, form two such areas. In these districts measures can be taken to increase the amount of non-cereals grown in proportion to cereal crops in locust years. This has been done to a small extent in parts of the Northern Province, the production of yams being taken up to a much larger extent than heretofore. In the Keta District, cassava is also being grown on a much more extensive scale.

One cannot, however, expect the population of any one particular area to change its diet on account of locusts which may occur only once in a generation. One hopes that as a result of research it will be possible to anticipate future invasions.

DIRECT CONTROL.

Destruction of Adult Swarms.

The destruction of swarms in the migratory phase is an unpracticable proposition. An enormous amount of material would be required in any event and one would necessarily be dependent on immediate reports and rapid transport. A small proportion of a swarm can be destroyed by burning when it settles for the night. This naturally depends on the state of the surrounding vegetation at the time, and usually only results in scattering the swarm—only for it to join up again later.

Control of adults becomes more practicable when they have reached the limit of their flight and are circling various districts during the dry season, an example being the dry season invasion of Togoland. Swarms are then very less active and numbers can be destroyed by burning. One is dependent on this being done by the local population. Unfortunately the farmers' interest in locusts is at a minimum at this time as he has no crops to be destroyed. Burning has a tendency to scatter the swarms, only for them to reform at some later date.

Destruction of Eggs.

In order to destroy egg pods, digging up of the areas where oviposition has taken place and exposing the egg-masses to the sun has been recommended. In this country this method can be considered impracticable. Oviposition frequently occurs in bush and is frequently scattered, areas being therefore difficult to locate. Exposure of the eggs to the air does not necessarily result in the prevention of hatching and may result in premature hatching.

Burning.

The simplest method of burning consists of scattering burning grass or straw over bands when they are resting at night. This method is impracticable in this country as hoppers, once they have gathered together into migratory bands, always climb up on to

(Photo by H. A. Dade)

Locust swarm in flight, as seen from below

grasses at night and the method therefore, only results in scattering the band. Other methods consist of surrounding a band with a ring of fire which eventually destroys it. The band can also be driven into burning bush if a sufficient number of beaters are present. The latter two methods can only be applied to small scattered bands. A number have been destroyed in this way following scattering and reforming subsequent to the use of other methods of control. Burning depends entirely on the dryness of the vegetation at the time.

The use of flame throwers has been advocated in other countries but is of little use in a country such as this, on account of expense and the danger to the operator.

Trenching.

This is one of the simplest forms of control and has been superseded in most countries by other methods. In the Gold Coast this method has been found the most practicable in the absence of poison-bait.

A trench, preferably three feet deep and three feet wide, the length and shape of which depends on the size of the band, is dug as near as possible in front of a band of hoppers. The sides of the trench should be vertical or preferably concave. The direction of movement is ascertained the evening before and the trench dug before movement commences the following morning sufficiently far away from the band to prevent it from being disturbed. As soon as movement commences the band is allowed to advance or is slowly driven in the direction of the trench. When driving is resorted to it is essential that the beaters advance in line and that no pockets are formed otherwise numerous hoppers will escape the line of beaters. Theoretically no one should be allowed near the trench when the drive is taking place. In practice it has been found that, however well a trench is constructed, the hoppers have no difficulty in climbing the sides and continuing their advance. This method has been modified with successful results by banking up the earth removed from the trench in the form of a rampart on the opposite side of the trench to the band. In addition to the line of beaters a number of labourers, preferably small boys, are employed kneeling behind the trench waving branches of trees or palms thus preventing the hoppers from climbing the sides of the trench. As the drive closes in on the trench and the latter fills up, the hoppers that climb the trench are beaten back by those behind. Two or three drives have been found necessary before an entire band is destroyed, and, where sufficient labour has been available bands up to one square mile in extent have been almost entirely destroyed. Driving depends on there being an abundance of free labour. In the most densely cultivated parts of the Northern Province of the Northern Territories where the danger to crops has been the greatest, free labour for this purpose has always been advisable and failing the use of poison, has been found the most effective. The method is laborious and takes many times longer than using poison but has been found the most practical when dealing with a

primitive population such as is found in the Northern Province of the Northern Territories where it has not always been considered wise to put down poison.

Erection of Barriers.

This is a modification of the trenching method. The movements of a band of hoppers are studied the evening before and, assuming that the same direction will be taken up the following day (almost always the case), a barrier consisting of cloth or galvanized iron is erected in front of the line of march. The length and shape of the barrier depend on the size and extent of the front of the band. Pits are dug at intervals inside the barrier to trap the hoppers as they come up against it and turn off side-ways. Strips of iron can be laid to overlap the edges of the traps to prevent the hoppers from climbing out. The hoppers are then allowed to proceed the following morning when they come up against the barrier and fall into the traps. Theoretically no one should be near the pits at the time of march as the direction may be changed and the barrier rendered useless. As soon as the pits are reasonably full the hoppers are destroyed by crushing. Frequently the barrier method is coupled with driving. In this way the process is hastened and no change of direction allowed. A considerable amount of labour, however, must be available. This method of control, usually results in a large number of hoppers escaping the beaters and reforming elsewhere. Disadvantages of the method are the amount of material that has to be carried about from place to place and that it can only be used in open country.

Barriers consisting of calico cloth and bordered at the top with an overlapping strip of American cloth to prevent the hoppers from climbing over were employed during the early part of the 1930 campaign. They were found impracticable as the hoppers found no difficulty in climbing over and frequently ate the cloth. This method was eventually abandoned in favour of trenching.

Poison-Baits.

The poison-bait method of control has been described in detail by Uvarov (4), and, in other countries has superseded any other method of control. The method consists of spreading some attractant material over, or in, the line of march of a band of hoppers. The advantage this method has over others is that (1) it does away with the use of large numbers of usually inefficient labourers ; (2) it can be used effectively in areas that are sparsely populated ; (3) its killing properties are by far the most efficient.

Preparation of Bait.

The normal bait consists of carrier, attractant and poison in various proportions. The experience in this country has been that the use of an attractant as an addition to the bait has been found unnecessary, the carriers themselves being sufficiently attractive. Success has been obtained with the following carriers, (1) dried horse or donkey manure (cattle manure is useless) ; (2) chopped up fodder

or reed grasses (*Pennisetum* spp.); (3) the chaff left after the threshing of guinea corn; (4) "*Dusa*", the local name for the waste left after the manufacture of "*Peto*" beer from guinea corn, and used as fodder. Choice depends on the quantities available in localities where the bait is being used. Dried horse manure, when available, has been found the most efficient and the safest to use. Sodium arsenite has been used as the poison. Following a series of experiments by Cook the following proportions have been found effective :—

Carrier	... 25 lb.
Sodium arsenite ...	... 4 oz.

The most convenient measures to use are a half-cigarette tin (tin of 50) of poison and two kerosene tins (eight Imperial gallons) or one kerosene box of carrier.

When using horse manure the carrier is kneaded to the consistency of coarse tobacco. The sodium arsenite is dissolved in sufficient warm water to make the whole preparation slightly damp when added, and usually amounts to two gallons. The solution is then poured slowly over the heaped-up carrier and thoroughly mixed. The final preparation should be of such a consistency that when spread by hand it covers the ground evenly without forming lumps. "*Dusa*" has been used only as an additional attractant on account of the small quantities usually available.

When horse manure has not been available in quantity, fodder grasses have been used with almost equal success. The grass is chopped up into lengths of from one to one and a half inches, and, where horses and cattle are kept, the local population is expert in carrying out this operation as fodder is always given in this manner. A disadvantage is that its spreading power is not as good as that of manure but it has been found to retain its efficiency for a longer period after rain. Another disadvantage is that it is liable to be eaten by small live-stock which are allowed to run free over cultivated areas. The same disadvantage applies when "*dusa*" and the chaff from guinea corn are used.

The following table gives results obtained by Cook in June, 1930. No exact method of determining the percentage dead at a given time could be effected. Estimation was therefore made from casual examination of the bands after treatment. A band was recorded as completely destroyed when either none or a very few isolated individuals were seen alive after a careful survey. The following factors were noted to observe what effect they had on the results; (1) Size of band; (2) Instar; whether 1st, 2nd, 3rd, 4th, or 5th stage; (3) Density of bands; (4) Type of country; whether thick bush, bare ground, thick grass, open farms, etc., (5) Time of application of bait; (6) Amount of bait used; (7) Weather conditions immediately before, and 12 hours after spreading; (8) Condition of bait 12 hours after spreading; (9) Percentage dead (approximately) 12, 24, 36 and 48 hours after spreading.

Place.	No. of Bands.	Instar.	Size of Band.	Time treated.	Bait used.	Weather conditions for 12 hours after treatment.	Condition of bait 12 hours after application.	Result after 48 hours.
Tamale ...	4	late 5th moulting to adult.	Yards. 40 x 50 to 20 x 15	Evening ...	Horse Manure	Fine	Dry ...	None dead.
Chessogo	12	2nd and 3rd	30 x 30 to 15 x 15	Evening ...	Horse Manure	Fine	Dry ...	Completely exterminated 98 per cent dead in 36 hours.
Chessogo	2	2nd and 3rd	15 x 20	Evening ...	Horse Manure	Heavy rain immediately after application.	Washed away.	25 per cent dead. No economical effect.
Bullung	3	3rd	30 x 30	Early morning	Horse Manure	Fine	Dry ...	Completely exterminated. 95 per cent dead after 24 hours.
Bullung	2	3rd	35 x 30	Mid-morning cloudy.	Horse Manure	Heavy rain prior to application cloudy ; fine after	Damp ...	95 per cent dead after 24 hours.
Bullung	1	3rd	20 x 20	Evening ...	Horse Manure	Fine	Dry ...	Completely exterminated.
Bullung	1	3rd	15 x 20	Evening ...	Grass ...	Fine	Dry ...	Completely exterminated.
Tumu ...	4	3rd	30 x 30 to 5 x 10	Evening ...	Horse Manure *Dusa*	Fine	Dry ...	Completely exterminated.

Place.	No. of Bands.	Instar.	Size of Band.	Time treated.	Bait used.	Weather conditions for 12 hours after treatment.	Condition of bait 12 hours after application.	Result after 48 hours
			Yards.					
Tumu ...	2	3rd	40 x 50	Early morning	Grass, horse manure and *Dusa* in strips	Fine	Dry ...	Completely exterminated. 95 per cent dead after 24 hours.
Tumu ...	1	5th	25 x 30	Early morning	Grass and Horse Manure	Heavy rain immediately after application.	Wet ...	93 per cent dead.
Tumu ...	2	5th	15 x 10	Early morning	Grass ...	Fine	Dry ...	Completely exterminated.
Pulima ...	3	1st and 2nd two days old	30 x 30	Evening ...	Horse Manure	Fine	Dry ...	38 per cent dead. No economical effect.
Pulima ...	1	1st. 4 days old.	25 x 30	Evening ...	Horse Manure	Fine	Dry ...	Completely exterminated. 95 per cent dead after 24 hours.
Pulima ...	7	1st and 2nd	90 x 30 to 10 x 15	Evening ...	Horse Manure	Heavy rain in night.	Wet ...	15 per cent dead. No economical effect.
Pulima ...	2	1st and 2nd	20 x 20 to 15 x 20	Evening ...	Grass ...	Heavy rain in night.	Wet ...	Completely exterminated. 98 per cent dead after 24 hours.
Pulima ...	5	2nd	30 x 35	Early morning	Grass and Manure	Fine	Dry ...	95 per cent dead. Thick grass and vegetation in area.

Place.	No. of Bands.	Instar.	Size of Band.	Time treated.	Bait used.	Weather conditions for 12 hours after treatment.	Condition of bait 12 hours after application.	Result after 48 hours.
Pulima ...	2	2nd	15 x 20 yards.	Evening ...	Grass ...	Fine	Dry ...	Completely exterminated.
Sekai ...	1	3rd and 4th	20 x 20	Morning ...	Horse Manure *Dusa.*	Fine	Dry ...	Completely exterminated. 95 per cent dead after 24 hours.
Sekai ...	2	3rd and 4th	15 x 20 to 20 x 20	Morning 9.30 a.m.	Grass ...	Heavy rain previously : then fine.	Damp ...	Completely exterminated. 95 per cent dead after 24 hours.
Sekai ...	1	5th	30 x 30	Early morning	Horse Manure *Dusa.*	Fine	Dry ...	Completely exterminated. 95 per cent dead after 24 hours.
Dange ...	2	3rd and 4th	50 x 50 to 40 x 40	Early morning	Grass : only ¾ covered.	Wet night previously, fine after.	Dry ...	Completely exterminated. 95 per cent dead after 24 hours.
Lilixia ...	5	4th	50 x 50 to 20 x 15	Early morning	Grass ...	Wet night previously, fine after	Dry ...	Completely exterminated. 98 per cent dead after 24 hours.

These results were obtained from bands personally investigated by Cook. They represented a fair selection, comprising every condition of ground, of bands treated during the course of the ordinary locust campaign. It demonstrates the lack of effect on first stage hoppers within a few days of hatching, and on fifth stage hoppers in the process of moulting to the adult stage when little or no feeding takes place. It also demonstrates the lack of effectiveness of bait after heavy rain, particularly when horse manure is used, and, that grass bait retains its effectiveness longer under wet conditions.

Under dry conditions grass bait does not retain its efficiency more than two days but has been found to have a quicker effect on fifth stage hoppers.

The time of application of bait, whether morning or evening, demonstrates that feeding takes place chiefly in the morning before movement takes place. Bait applied in the evening resulted in a mortality of 98 per cent after 36 hours, and in the morning of 95 to 98 per cent after 24 hours, i.e. the following morning. During the rains, therefore, bait should be applied in the morning as rain rarely occurs before noon.

It has been found that an area of approximately 400 square yards can be covered by one kerosene tin full of bait. In practice this amount can be made to go much further by judicious spreading. A band can be ringed or a belt of poison put down in front of its line of march. A poisoned band tends to remain in the vicinity and as individuals die off they are eaten by others the poison thus having a progressive effect. So far it has been found that bait is effective in all habitats, the quickest mortality being found in those environments that include areas of bare soil. The effect of thick vegetation only appears to delay the result by a few hours. Here, however, greater amounts of bait are necessary.

The bait is spread by hand in the same way as broadcasting seed. Labourers soon become proficient in this method of spreading.

The poison-bait method has not yet been used in Southern Togoland or the Keta-Ada District of the Colony. Vegetation is considerably thicker than in the Northern Territories and larger proportions of bait are therefore necessary. In the latter districts, horse manure is not available and local grasses have to be relied upon.

The advantages of the use of poison bait over other methods is clearly demonstrated and is vastly superior to mechanical methods as the operator does not require any skilled technique.

Precautions necessary when using Bait.

When using a highly dangerous soluble poison such as sodium arsenite great care is necessary on the part of the operator

particularly at the mixing area. It is essential that anyone who has had contact with the poison should wash himself after the mixing operation is finished and that all receptacles that have been used for mixing poison are afterwards destroyed. The danger of accident when dealing with a primitive population is naturally high and precautionary measures must be employed which would not ordinarily be necessary. In cattle-rearing districts, such as the whole of the Northern Province of the Northern Territories, fatalities have resulted from cattle obtaining access to previous mixing centres where free arsenic has been allowed to remain on the soil. Cattle, horses and sheep, etc., are attracted apparently on account of the salt. When mixing it is advisable to dig a hole from two to three feet deep and approximately three feet square alongside the mixing area. At the end of the operation all mixing utensils, stirring sticks, etc., that are not required again, are thrown into the hole. The top three to six inches of soil under the mixing area are then scraped into the hole and any surplus water thrown over the lot. The hole is then filled in.

A great deal of the danger from mixing centres can be avoided if centres for the distribution of bait are made. Such a centre can be surrounded by a low wall to keep out cattle and can also be guarded. There is little danger after the bait has been spread. It has been considered unwise to spread the bait over bands located in farms, particularly on those in close proximity to native compounds. Live-stock are always allowed to over-run compound farms and, unless controlled, fatalities may occur. This has happened when grass and *dusa* have been used but not manure. Poison-bait loses its effectiveness after three or four days, therefore, if the people are warned to keep their live-stock away for this period, no danger should result. It is considered unwise to put down bait on farms interplanted with soup plants, *Sesamum*, and *Hibiscus* spp.

It is necessary to point out the importance of warning the local inhabitants when poison is employed. Kerosene tins are greatly in demand and if one that has been used for poison is taken away, serious results are likely to result. Locusts are considered a local delicacy and it is quite within the bounds of possibility that poisoned locusts may be collected for the pot. Care must be taken during transportation of the bait from the mixing base to the area to be treated. As the bait dries after manufacture, arsenic tends to crystallise out on the exterior of the bag or basket used for transport.

In the event of a similar hopper outbreak in 1931 it is proposed to use the poison-bait method on a much larger scale, particularly in Togoland. Previous experience has shewn the value of this method over any other and precautionary measures have been evolved which do away with the risk of danger that has previously occurred.

(Photo by H. A. Dade)

Locust swarm settling for the evening meal

BIONOMICS OF THE MIGRATORY LOCUST IN THE GOLD COAST.

LIFE HISTORY.

Oviposition and Incubation.

Oviposition has previously been described by Cook (1) and takes place at the end of the migratory flight and usually occurs after rain—localities being chosen where the soil is soft, and bare of thick grass vegetation. Typical oviposition areas are (i) areas of burnt grass with a carpet of fresh young grass, (ii) open areas in the neighbourhood of swamps and streams with plenty of succulent grass in the immediate vicinity, (iii) cleared farm land.

Oviposition areas can be recognised by the numerous holes drilled in the ground by ovipositing females. A cylindrical egg-mass or pod is laid two or three inches below the surface, the mass being bound together with mucilage, the hole being afterwards caulked with mucilage with the result that a hole in which eggs are laid is hardly recognisable from above. Numerous holes are drilled by a female before selecting one in which to place her eggs, hence the appearance of the ground.

The number of eggs laid by one female is not known nor is the number of times when oviposition takes place but the latter is probably once or twice, a number dying after each oviposition.

The eggs are banana-shaped, 6 to 7 mm in length and light yellow when first laid, expanding and turning brown as the incubation period advances. An egg-mass consists of from 50 to 100 eggs.

The incubation period is variable and influenced to a large extent by temperature and moisture. The shortest time observed under laboratory conditions has been 11 days and the longest 23, with an average of 19 days. Under field conditions the average period is undoubtedly shorter and probably ranges from 10 to 15 days. Rainfall favours hatching, incubation being prolonged when conditions are dry. It has been suggested that eggs laid at the end of the dry season will remain over until the following rains. To date, there has been no record of this occurring in the Gold Coast. All mature swarms here, invaded this country during the rainy season when conditions have been favourable for oviposition. Those invasions that have occurred at the end of the rains or during the dry season have been immature and have only reached maturity after the rains have commenced. Instances of possible delayed hatching have been recorded but have resulted either from an unrecorded swarm, or from a prolonged incubation period due to local conditions being unfavourable to hatching at the time.

The newly hatched hopper emerges as a vermiform larva, i.e. totally enclosed within a transparent membrane. A few seconds after reaching the surface this skin is cast and the true first nymph emerges.

There are five nymphal stages of varying periods before the adult stage is reached, the nymphal skin being cast between each stage.

The first stage hopper is pale yellow-grey when newly hatched, darkening to a dull black as the stage advances, with a pale yellow median stripe along the back and pale yellow banding on the hind femora. The newly hatched hopper is 8 to 10 mm. in length.

In the second stage the general yellow colour of the older hoppers commences to appear. The head and thorax are pale yellow on the sides with a white spot on each side of the latter, black on the dorsal surface of the thorax, and a median yellow line down the middle of the thorax and abdomen. The length immediately after moulting is 13 to 15 mm.

In the third stage the rudiments of the wings appear as distinct triangular markings projecting back from the thorax. The yellow marking is more distinct and the dorsal surface of the thorax, and to a lesser extent, the head and abdomen are jet black with a narrow yellow median line down the centre of the thorax. The length is about 16 mm.

The wing rudiments become more distinct in the fourth stage. The side of the head and thorax are yellow with a distinct orange tinge. The dorsal surface of the thorax is jet black with a distinct median yellow line ; the abdomen dull brown. The length is now approximately 24 mm.

The orange tinge on the side of the head and thorax and also on the legs becomes much more marked in the fifth stage, and the wing rudiments much larger, the latter covering half the length of the abdomen. The dorsal surface of the thorax is as before ; the median line on the thorax having a distinct orange tinge.

The length of the nymphal life is variable ranging from 40 to 60 days. Nymphal life during the September hopper infestation of the Northern Province was observed to be approximately 48 days.

Behaviour of Hopper Bands.

Immediately after hatching the young hoppers gather together into so-called primary bands on the oviposition area ; little feeding taking place, the hoppers clustering together on stones and bare patches of soil to obtain the full benefit of the sun. Later, generally in the second stage, the bands join up and migratory movement commences. Activity is influenced by temperature. As the temperature falls in the latter part of the day the hoppers climb

up on the stems of grasses where they rest for the night, descending again as the temperature rises in the morning to continue their advance. If it becomes too hot during the day, movement again ceases. Direction, with few exceptions, is with the prevailing wind. They are easily disturbed, however, and the direction changed, the original direction only to be resumed later on. As the country commences to dry up following the cessation of the rains, migratory bands tend to congregate in the vicinity of standing water. Bands also tend to follow bush tracks and roads on account of the heat radiated from the exposed soil. Bands also have no difficulty in swimming rivers of considerable breadth.

The tendency to follow the prevailing wind and open spaces such as roads, etc., is of considerable aid to their control.

Behaviour of Flying Swarms.

Rate of flight has depended almost entirely on the strength of the following wind, the speed of individuals in any one swarm varying from 3 to 15 miles per hour. During the November invasion of the Northern Province the leading members of a swarm settled on the ground in front not rising until the remainder of the swarm had passed. Flight was therefore in the form of a flattened wheel the mean speed being approximately half that of individual members in the swarm. The distance covered in one day is very variable depending on temperature but a distance of 30 miles was recorded during the November invasion.*

Adult swarms are influenced by the same factors as hopper bands, movement being affected by temperature. Settling for the night commences in the early evening as soon as the temperature falls, the area chosen being circled for some time before final settling. Adults climb up on the stems of grasses and trees, branches of the latter frequently being broken off, in order to obtain the benefit of the extra heat a few feet above the surface of the ground and the last rays of the sun. On dull days flight may not take place at all. As soon as the temperature rises in the morning, flight recommences, individuals fanning their wings to dry off the dew prior to taking off If the temperature becomes too hot during the day, swarms frequently re-settle taking off as soon as the temperature falls.

The November and December invasion of the Northern Province took place after the dry season had commenced and when the country was rapidly drying up. All swarms tended to settle in the vicinity of swarms and rivers on account of the succulent grass food available frequently staying two or more days at one place if that place was found suitable.

* At the time of writing swarms have been recorded as covering as much as 60 miles in one day. The mode of flight has not been observed by the writer but it is presumed that these flights were not of a circular nature and that no feeding was therefore taking place during the flight owing to the scarcity of food at the time.

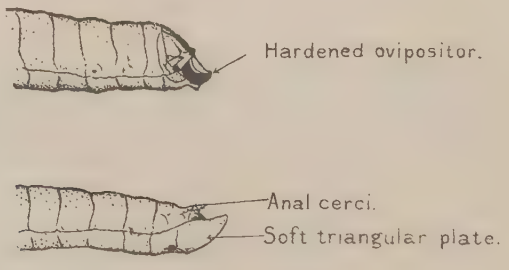
During a long migratory flight little feeding is done but as the sexual organs develop towards the end of the flight they feed voraciously. On first reaching maturity adults tend to congregate in the vicinity in which they were bred, frequently marching with the remainder of the band until they also become adult. Migration does not take place over any considerable distance until a sufficiently large swarm has been formed or until another swarm passes over with which they unite.

Description of Adults in various stages of maturity.

Freshly emerged adults differ in colour from those in a later stage of development and are easily recognised. Both sexes are very much paler in colour than the older adults the general body colour being pale grey with two distinct longitudinal black stripes down each side of the pronotum.

After the migratory flight has commenced the pronotal stripes disappear and the adults take on the typical bronze-coloured appearance which gradually darkens as they get older.

The two sexes are easily distinguished on account of the structure of the tip of the abdomen. The final abdominal segments of the female terminate in two pairs of strong black hooks, an upper and a lower, which form the ovipositor. Those of the male terminate in a soft yellowish triangular plate pointing upwards at the apex.



Final Segments of Abdomen of Female (upper figure) and Male (lower figure).

A period of from two to four months from final ecdysis (casting of skin) may pass before sexual maturity is reached, during which time the migratory flight in made. When sexually mature and when copulation commences, a bright canary yellow colour is acquired by the males, particularly on the legs, and to a lesser extent by the female, the latter retaining a large proportion of the bronze coloration. Sexually mature swarms are therefore easily recognised by the colour of the male*

* Adults brought up to maturity in the absence of direct sunlight did not shew this definite change of colour from bronze to yellow.

The degree of development of the sexual organs can easily be determined by dissection. The ovaries of the female consist of a large number of egg tubes. When sexually mature a large part of the abdomen is filled by these tubes whereas in the earlier stages of development they are hardly recognisable. If a female in a swarm is caught and the head carefully drawn away from the rest of the body most of the viscera is drawn with it with the ovaries attached The degree of maturity can then be gauged.

It is not known how long copulation occurs before oviposition or how many times the process may occur. A pair may remain in coitus for two or three days the male remaining in company with the female during the act of oviposition.

Food Plants.

The normal food of the Migratory Locust is confined to the *Gramineae,* grasses of the genus *Pennisetum* being particularly preferred.

Amongst cultivated plants in the Gold Coast the following have been readily attacked :—

Early Millet (*Pennisetum typhoideum.*)
Late Millet (*P. spicatum* var.)
Guinea Corn (*Sorghum vulgare.*)
Maize (*Zea Mays.*)
Rice (*Oryza sativa.*)
Bamboo (*Bambusa* spp.)

Reports have been received of cassava and groundnuts being attacked but none of these reports has been substantiated. Elephant Grass (*Pennisetum purpureum*), a local fodder grass (probably *Pennisetum polystrachyon.*) and Nut Grass (*Cyperus* sp.) have also been readily attacked, the first being the chief article of diet in savannah country.

Adult swarms that invaded the country during the dry season were frequently observed to feed on other cultivated plants and caused considerable defoliation. Most of these plants can be considered as providing accidental food on account of the normal food being absent or unfavourable at the time. These plants have been :—

Coconut Palm (*Cocos nucifera*)
Oil Palm (*Elaeis guineensis.*)
Plantain and Banana. (*Musa sapientum* spp.)
Pine-Apple (*Ananus sativus*).

These plants have only been attacked by adults and it is of interest to note that all food plants have been confined to monocoyledons.

Occurrence of Variants.

During driving operations in September and October, in the Northern Territories a number of green and yellow individuals

(Fig. 6 opposite) as distinct from the ordinary orange and black coloured hoppers, were observed in the bands, the proportion being frequently as high as 2 per cent. They were first thought to be hoppers of a different species of grasshopper accidently collected in the drive. In places where bands containing these different coloured hoppers had previously been breeding a number of green adults were also observed which had broken away from the remainder and remained in the vicinity. They are undoubtedly adults in the transitional stage between the swarming and solitary phase.

Natural Enemies.

PREDATORS.

Considering the size of swarms that have occurred in the Gold Coast the number of insectivorous birds that are attracted is small. The Tick bird of the Northern Territories (*Herodius alba*) has been observed feeding on swarms but as this bird only occurs in the Gold Coast during the dry season it forms only a moderate check. In the Gold Coast where swarms have entered the forest country during the dry season the African Crow (*Corvus africanus*), and various species of hawk, have been observed attracted in considerable numbers and no doubt account for a considerable quantity.

PARASITES.

No egg parasites have yet been observed nor has parasitism been observed in the hopper stage. The larva of a Sarcophagid parasite has frequently been obtained from mature females at the time of oviposition. This parasite completes its life-history in the thorax passing out through the abdomen, when mature, and pupating in the soil. The adult fly has not yet been identified.

Natural enemies have not played an important part in the control of the locust in this country as yet. This is to be expected with a migratory insect which only at very infrequent intervals invades new territory. It is probable that parasitism will increase as the swarming phase is ending.

CONDITIONS THAT RESULT IN SWARMING.

Between each swarming phase the Migratory Locust exists and behaves as an ordinary grasshopper, that is, it does not require to embark on a long migratory flight before it is capable of becoming sexually mature. This phase is known as the solitary phase, and in the case of the Migratory Locust in Southern Europe, has been described as a separate species. The phase is dependent for its breeding grounds on perennial swamps which contain a large amount of luscious grass vegetation. These areas are known as permanent breeding grounds.

The conditions necessary for the change over from the solitary to the swarming state are not fully understood but are probably

Fig. 1.
First Instar
Hopper.

Fig. 2.
Second Instar
Hopper.

Fig. 3.
Third Instar
Hopper.

Fig. 4.
Fourth Instar
Hopper.

Fig. 5.
Fifth Instar
Hopper.

Fig. 6.
Fifth Instar
Variant.

Hopper Stages of the Migratory Locust

(slightly enlarged).

climatic. Once extensive breeding has commenced in the permanent breeding grounds, the hoppers tend to congregate in bands thus increasing the congestion, and, failing other conditions arising to check the increase, the tendency to change over to the solitary stage is intensified and a vicious circle formed, the change over becoming progressive.

The first invasion of this Colony in November, 1928, and subsequent invasions, have originated in the north. No records have been obtained of the flights of locusts in Haute Volta but it is presumed that this territory was invaded some time previous to the first Gold Coast invasion. The original swarms may have originated in the large perennial swamps in the neighbourhood of Timbuctoo, on the Niger River in French Senegal, or in the swamp district in the eastern corner of French Haute Volta just north of Dahomey. Both of these areas form ideal areas for the breeding of the solitary form.

Observations are necessary on the habits of the solitary form in their permanent breeding grounds in order to obtain information on the conditions that result in swarming. Before this can be done it is essential that these permanent breeding grounds be located.

It is hoped that records from French Haute Volta will eventually become available and that it will be possible to correlate the swarms that occurred there, with the Gold Coast invasion.

INDEPENDENT BREEDING GROUNDS IN THE GOLD COAST.

No district in the Gold Coast as yet forms a permanent breeding ground. Independent breeding has been previously referred to in various localities that cannot be correlated with any outside invasion. Such areas have been indicated as being the Afram plains, the swamp area between Akuse and Adidome alongside the River Volta and in Kusasi District in the Northern Territories. There are no doubt many others. In these areas succulent grass vegetation is abundant throughout the year and conditions are similar to those that occur in permanent breeding areas. These areas have only resulted in independent breeding during the present infestation but it is always possible that some may become permanent breeding grounds subsequent to being stocked with the solitary form.

Conditions that result in the cessation of the swarming phase are not yet fully understood but the reverse to that which causes swarming must obviously occur, that is, reduction in the size of hopper bands. They may follow unfavourable climatic conditions, or heavy parasitism, with a subsequent thinning out and scattering of swarms resulting in an increase in the number of individuals tending to return to the solitary phase.

The present position at the time of writing indicates that this is now occurring and that this year (1931) will see the completion of the present swarming phase.

SUMMARY.

1. During January, 1930, small flights traversed the Northern Territories, Southern Togoland and the Trans-Volta District of the Colony, being the remnants of those swarms which invaded the Colony from French Haute Volta in September and October, 1929.

2. Southern Togoland and the Trans-Volta District were again invaded from French Togoland and from the Afram plains in March 1930, these swarms being sexually mature. Oviposition took place in the Keta-Ada District, in the Akuse District, and was scattered over the Accra plains and in the Cape Coast District, hoppers being reported in these localities shortly after.

3. Hatching of hoppers coincided with the planting of corn which was subsequently attacked, necessitating the institution of control measures. Surviving individuals eventually flew off in a north-easterly direction.

4. In March, oviposition also took place on a comparatively large scale in the Southern Province of the Northern Territories, hoppers occurring in April. Subsequent adults flew off to the north.

5. Early in May the Northern Province of the Northern Territories was invaded from the east, oviposition being chiefly confined to the Wa, Lawra and Tumu Districts. Hoppers were prevalent in these districts in June and seriously threatened the early corn crop necessitating the undertaking of extensive control measures when trenching and driving were resorted to. The major part of the damage was done by those swarms responsible for oviposition.

6. During July and August, except for a very few scattered hopper bands, the whole of the Colony was free from locusts.

7. Early in September the north-eastern districts of the Northern Province were again invaded from French Haute Volta, oviposition taking place on an extensive scale in Kusasi, Zuarungu, Mamprusi and Navrongo Districts and to a lesser extent in Tumu District. Localised damage was done by the invading swarms. Hoppers occurred late in September and during October and part of November Control measures were again undertaken which consisted of trenching and driving and the use of poison bait, successful results being obtained with the latter. Hoppers caused relatively little damage, cereal crops being sufficiently far advanced; feeding was almost entirely confined to grasses.

8. In November further swarms again entered the north-eastern districts from French Haute Volta and from French Mandated Togoland. These swarms were immature and travelled westwards, the majority re-entering French Territory in Tumu District. A few travelled south towards the Afram plains whilst others invaded Northern Ashanti in the neighbourhood of Wenchi. These swarms caused no damage to cereal crops in the Northern Territories but localised damage was done to maize in Northern Ashanti.

9. Southern Togoland and the Eastern Province of the Colony were again invaded in November from the Afram plains and from French Togoland, swarms being immature. Localised damage was done to late maize particularly in Akuse District. As the dry season advanced, swarms split up and circled erratically and later a number of branches invaded the forest country. Coconuts, oil palms and plantains were attacked owing to the absence of normal food.

10. Independent breeding was found to have occurred on a small scale in Keta-Ada District during December and to a larger extent in the vicinity of the Afram plains.

11. The various measures of control are discussed. Poison-bait consisting of sodium arsenite, using horse manure or chopped-up grasses as the carrier, was found to be the most effective but cannot be used in all localities. Total extermination of hopper bands can be obtained by the latter method.

12. The bionomics of the Migratory Locust are briefly discussed. The life-history is variable being chiefly influenced by temperature. The incubation period ranges from 10 to 15 days and the nymphal life (time of hatching to the adult stage) from 40 to 60 days.

13. Hopper bands frequently contained individuals distinct in coloration from normal hoppers. These are a transitional stage between the swarming and solitary phases. The Migratory Locust exists as an ordinary grasshopper between periods of swarming, no long migratory flight being necessary before becoming sexually mature.

14. Normal breeding grounds of the solitary phase occur in perennial swamp and are known as permanent breeding grounds. It is improbable that permanent breeding grounds occur in this country. It is suggested that permanent breeding grounds from which the present swarming phase arose are in the vicinity of the River Niger in French Senegal. To cope with future invasions it is essential that permanent breeding grounds are located and that the conditions necessary for the change over to the swarming phase are thoroughly studied.

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PAPER No. XXXII.

WORK OF TAMALE INVESTIGATIONAL STATION, SEASON 1929 AND 1930.

By G. COWAN.

INTRODUCTION.

This is the first general report to be published since the Investigational Station was started in 1926. Work on cotton has always been the main object, but more attention, particularly during the last two seasons, has been paid to food crops. A list of papers already published dealing with the work of the station is to be found as Appendix A to this report.

The main lines of work are now four in number :—

A. Cotton trials and selection work.
B. Special investigations.
C. Food crops trials.
D. Farming systems.

These are discussed below.

A. COTTON TRIALS AND SELECTION WORK.

Work on the above was started in 1926 when a power ginnery was installed at Tamale. Allen cotton seed from Northern Nigeria was imported and 40 acres of cotton were grown on the station.

The mean yields on the station since that year were as follows :—

	Area Planted.	*Mean Yield.*
1926–27	40 acres	18 lbs. per acre.
1927–28	40 acres	34 lbs. per acre.
1928–29	93 acres	40 lbs. per acre.
1929–30	10.5 acres	54 lbs. per acre.
	9.8 acres	87 lbs. per acre.

An account of selection work and field trials carried out in the 1928–29 and 1929–30 seasons has already been published in the 1929 Year-Book (Papers XXXV and XXXVI), and a full report on the continuation of this work during the season 1930–31 is contained in this Year-Book. Field trials conducted during the season 1930–31 included:—

(1) Optimum time–planting trial with Allen and Ishan varieties—a repetition of the 1929–30 trial.

(2) Artificial manurial trial with Allen cotton—following a trial with pen manure and Bengal beans in 1929–30.

B. SPECIAL INVESTIGATIONS.

Shea.

In 1930 special machinery was imported and installed, and investigational work, with the extraction of Shea butter as the main study, will now be possible. It is also proposed to carry out work on the extraction of groundnut oil.

Drainage.

Drainage problems are being investigated and a study of the methods to be adopted to prevent losses by erosion has been started. Data are being collected from native farms in order to gain more knowledge of this subject.

Types of soil.

The types of soil, and concurrently the crops grown, have a great influence on the measures of control of water and soil movement, but the study of the problem is not, as yet, sufficiently far advanced to provide a complete account of this subject.

C. FOOD CROP TRIALS.

The district in which the station is situated is an extensive yam-growing area where a system of mixed cropping and shifting cultivation is practised. Whilst under cultivation, rotational farming of the land is adopted—each course consisting of one principal crop interplanted with subsidiary crops. The range of subsidiary crops which may be interplanted varies with the principal crop in the course : it is greatest when the latter is yams. Occasionally, however, single cropping is met with.

Information from the station therefore must be sought for on crops grown both singly and in admixture. This information should supply answers to both agricultural and economic questions.

In addition to the testing of varieties and strains of crops grown under different conditions, selection work was also carried out.

The following list shows the trials laid down in 1929 and 1930 :—

1929.

(1) Variety yield trial with four varieties of yam.

(2) Yield trial with two strains of rice.

(3) Combined spacing and time-planting trial with indigenous maize.

(4) Combined spacing and variety yield trial with two varieties of groundnut. (The groundnuts in this experiment were attacked by *kuturu* disease and the results of the trial were rendered valueless).

1930.

(1) Variety trials with yams (five varieties) grown with interplanted millet.

(2) Spacing trial with groundnuts.

(3) Experiment to test the effect on interplanted millet of five varieties of yam.

D. FARMING SYSTEMS.

Under the system of farming practised in the district (as explained under "C." above), the farmer uses different crop rotations on different soil types. These rotations vary in the kind of crops grown and their admixture, their sequence, times of planting, spacing, size of ridges and periods during which the land lies fallow.

These local practices are presumably the outcome of experience, and, before attempts are made to improve this husbandry, it is essential that trials be carried out by the Department over a wide range of soils to ascertain yields and labour costs. It may be that the law of diminishing returns operates and that further yield increases are gained only by an additional, disproportionate and uneconomic amount of labour.

Information on these points is being sought and the following list of trials have been laid down in 1929 and 1930 :—

1929.

(1) Rotation trials :

(*a*) five course with green manuring.

(*b*) three course with green manuring.

(2) Trials on the establishing of Bengal beans in conjunction with catch crops.

(3) Mixed versus single cropping. (Crops : Maize, guinea corn and groundnuts).

1930.

(1) Rotations continued.

(2) Native systems of cropping.

(3) Green manure trials.

YIELDS OF FOOD CROPS GROWN ON TAMALE INVESTIGATIONAL STATION.

CALCULATED YIELDS PER ACRE.

Crop.	1928.	1929.	Mean of 1928 and 1929.	1930.	Remarks.
Yam ... 1.	—	9,970	8,155	7,110*	lbs. of freshly harvested tubers.
2.	—	6,341		5,030*	
Guinea Corn 1.	180	136	175	336	lbs. of dry threshed grain.
2.	143	121		441	
3.		214			
4.		256*			
Maize ... 1.	112	475	288	54* (early crop).	lbs. of dry threshed grain.
2.		448*			
3.		118			
Millet 1.		99	191	435*	lbs. of dry threshed grain.
2.		282			
Ground-nut. 1.	472 (on flat)	94*	400	831 Spacing	lbs. of freshly harvested nuts in shell.
2.	680 (ridged)	104*		564 Experi-	
3.	650 (ridged)			354 ment.	
Bambarra bean.	—	456	456	630	lbs. of freshly harvested nuts in shell.
Rice ... 1.	892 (local)	573 (Black selection).	492	286*	lbs. of paddy
2.		522 (Yellow selection).		552 (Black selection).	
3.		390 (Yellow selection).		666 (Yellow selection).	
4.		387 (Pindi variety).			
5.		346 (Attabubu variety			
6.		355 (American variety).			
Cowpea	—	142 (after maize).	142	—	lbs. of dry seed.
Cassava 1.	10,810	2,488 (8 months old).	7,187	—	lbs. of freshly harvested tubers.
2.	8,264				

* Grown in mixed cultivation.

It is not always permissible to compare the mean yields given above with the yields obtained in any one season. In some cases, when only a small acreage of a particular crop was grown in any one year, and the crop was a partial failure, this very considerably reduced the mean yield of the two seasons. Again, some of the crops have in one year been grown on what was found to be unsuitable soil, and comparisons between these yields and the yields obtained on suitable soil in a different season are only of cautionary interest.

Neglecting the invalid data, the year 1929 was outstanding in that the June rainfall was the lowest on record and was much below the mean of 20 years. This delayed the planting of groundnuts and the crop was a poor one in consequence. In 1930 the rainfall was again low in June (although higher than the previous year), but in May was much above the average. Although a certain amount of damage was caused by the excessive amount of rain badly distributed over the month, early planted crops benefited largely. With the exception of groundnuts in 1929, and rice in 1930, crops were normal, but the unusual *harmattan* experienced at the end of 1930 and the beginning of 1931 affected the flowering of cotton.

A. COTTON TRIALS.

As already stated, the results of work on cotton at Tamale Station have already been published for the seasons 1928–30 in the 1929 Year-Book, and for the season 1930–31 in a paper by Symond and Williams in this Year-Book. The field trials on cotton, therefore, will be dealt with only briefly here.

TIME OF PLANTING TRIALS WITH ALLEN AND ISHAN.

Season 1929–30.			Season 1930–31.		
	Allen. lbs. seed cotton per acre.	*Ishan.* lbs. seed cotton per acre.		*Allen.* lbs. seed cotton per acre.	*Ishan.* lbs. seed cotton per acre.
31st May ...	91	95	11th June ...	43	74
14th June ...	93	98	2nd July ...	27	55
20th June ...	115	101	23rd July ...	18	43
12th July ...	112	78	13th August ...	19	19
26th July ...	58	66	3rd Sept., ...	8	27

In both trials and for both varieties it would appear that June has been the best planting month.

The relatively high humidity recorded until January resulted in quite different flowering curves of the selections and varieties when compared with the previous year, but it is considered that the final yield was not conspicuously affected.

MANURIAL TRIALS.

Season 1929–30.			Season 1930–31.	
	Allen. lbs. seed cotton per acre.	*Ishan.* lbs. seed cotton per acre.		*Allen.* lbs. seed cotton per acre.
Pen manure ...	154	144	Basic slag and kainit ...	48
Control	75	64	Basic slag, kainit, and lime	47
Bengal beans ...	66	57	Basic slag	41
			Kainit and lime	37
			Slag and lime	36
			Lime	31
			Control (no treatment) ...	30
			Kainit	27

In the first trial, the application of pen manure more than doubled the yield of both varieties, and in the second trial, the greatest effect was obtained from the plots fertilised with basic slag.

B. SPECIAL INVESTIGATIONS.

Shea.

During 1929 seeds from selected trees on the Yendi Shea Reserve were collected and planted on a five acres block at Tamale. Growth has been poor to date and many vacancies have been filled. Details of this experiment will be found in Table I.

Yields.

Individual yields from three isolated Shea trees, which have been protected from fire, have been collected for two seasons and are given below.

	1929.		1930.	
	No. of nuts produced.	Wt. of dry kernels in lbs.	No. of nuts produced.	Wt. of dry kernels in lbs.
Tree No. 1	1,646	9.7	Nil	Nil.
Tree No. 2	496	4.1	6,456	34.0
Tree No. 3	1,674	11.2	18,507	131.0

Tree No. 3 is very large and the yield obtained from it in 1930 is outstanding.

C. FOOD CROP TRIALS.

YAM VARIETY YIELD TRIAL—1929 (*see* TABLE II).

Variety.	Yield of freshly harvested tubers (excluding those diseased).	Percentage of crop in quality grades.			
	Means of 4 plots (lbs. per acre).	1st Grade	2nd Grade	3rd Grade	Diseased.
Puno ...	9,795	74	17	3	6
Dapam ...	10,255	45	44	5	6
Zillambo...	10,400	23	50	21	6
Peringa ...	9,425	33	51	16	0

The planting material for this trial was obtained from local farmers, and, later in the season, the varieties were observed not to be pure enough for reliable conclusions to be drawn from the yields.

1st grade yams ... ... Large saleable tubers.
2nd grade yams ... ... Large and medium seed size.
3rd grade yams ... ... Small seed size, and "chats."

A large proportion of the Puno crop was 1st grade in contrast with the other varieties, especially Zillambo. This result appears to be normal to Puno, but the low percentage of 1st grade tubers in Peringa, and, to a slightly lesser extent, in Zillambo, is not typical. If a large amount of seed is required, the normal farming practice is to remove the large tubers in August or September, but since this was not done in the variety yield trial, the number of tubers of Dapam in each of the 3rd grades is fairly typical.

YAM VARIETY YIELD TRIAL—1930 (*see* TABLE III).

Variety.	Yield of fresh tubers (means of 4 plots in lbs. per acre).	Remarks.
Puno	8,415	Millet was interplanted with the yams.
Zillambo	7,605	Standard error of comparison of two variety means, calculated per acre 2,022 lbs.
Dapam	6,885	
Peringa	6,810	
Labaco	5,850	

The Puno variety yielded at the rate of 2,565 lbs. per acre more than the Labaco variety. This difference is significant.* In addition, Puno yielded 1,605 lbs. per acre more than Peringa and 1,530 lbs. more than Dapam ; Zillambo yielded 1,755 lbs. per acre more than Labaco. Each of the two last differences is not significant, being less than 2,022 lbs., but there are indications that in other trials under similar conditions, Puno might prove to be a heavier yielder than either Peringa and Dapam, and Zillambo might might be a heavier yielding variety than Labaco. Although the standard error limits the confidence that can be placed in the differential yields, the recorded results are still the best measure of the comparative yields, under the conditions of the experiment, with interplanted millet. This trial is being repeated next season, both with and without interplanted millet, and it should then be possible to measure the differential effect of interplanted millet on the yields of the five varieties.

Notes on the five varieties (*Dioscorea* spp.).

Dagomba names.

Labaco.—Early maturing, much liked for its flavour, but has poor keeping qualities ; white in colour.

Puno.—Mid-early ; very good for boiling, but does not keep too well ; white in colour.

Dapam.—Main crop variety ; good for most forms of cooking but superior to the other varieties in making *fou-fou* ; good storage qualities. Colour intermediate between Labaco and Peringa.

Zillambo.—Late maturing ; not eaten when freshly dug because then the flavour is poor ; excellent keeping qualities ; flavour improved with storage ; colour slightly yellowish.

Peringa.—Similar to Zillambo, but has a slightly better flavour

RICE SELECTION YIELD TRIAL—1929.
(*see* TABLE IV).

Selection.	Yield of paddy (means of 9 plots in lbs. per acre).	Notes.
Yellow-glumed	573	Standard error of the mean— 3.65 or 36.5 lbs. per acre. 't' = 1.39 'p' = 0.2
Black-glumed ...	522	
Difference ...	51 lbs. per acre.	

* The standard of significance unless otherwise stated is taken as P=0.05 (after Fisher.)

The two selections of yellow-glumed and black-glumed paddy were made in 1928 from fields of the local hill rice, which is usually grown in admixture with other crops—principally with yams. Although in this trial the yellow-glumed selection gave higher yields in seven out of nine pairs of plots and averaged 51 lbs. per acre more than the black-glumed selections, the mean difference in yields between the plots is not significant.

MAIZE COMBINED SPACING AND TIME PLANTING TRIAL—1929
(*see* TABLE V.)

Spacing on ridges 4′ apart.	Yield of undried grain. Means of 4 plots in lbs. per acre.		
	Time of planting.		Mean both times of planting for each spacing.
	"Early" (14th May).	"Late" (12th July).	
2 ft	692	278	485 lbs. per acre.
3 ft	482	218	350 lbs. per acre.
Mean both spacings for each time of planting ...	587	248	

The early planted maize (both spacings) yielded more than twice as heavily as the late planted: this result is significant. The recorded weight of grain from the maize planted 2 ft. apart, yielded nearly half as much again as that from the maize planted 3 ft. apart, but this result is not significant. The results were affected by the wide range of fertility in the land used for this trial: an examination of Table V, shews that the yields of plots ranged from 56 lbs. to 924 lbs. per acre. A better appreciation of the results may be obtained by examining the yields between each block, as given in the following table. The blocks are arranged in order of fertility as measured by the yield of maize.

	Blocks.			
	B.	C.	D.	A.
Average yield of maize (lbs. acre.)	612	425	358	275
"3 ft spacing" yield expressed as percentage of "2 ft spacing" for both times of planting	*per cent.* 95	35	81	91
"Late planting" yield expressed as percentage of "early planting" for both spacings	*per cent.* 98	36	14	16

Spacing.—In each of the blocks 2 ft. spacing was better than 3 ft. spacing, but not markedly so except on the medium soil of Block C. Possibly spacings closer than 2 ft. would prove successful.
Time of Planting.—In each of the blocks early planting gave better yields than late planting, but the superiority of early planting was very marked on the medium soil of Block C, and still greater on the poor soils of Blocks D and A.

EFFECT ON INTERPLANTED MILLET (*Pennisetum spicatum*) OF 5 VARIETIES OF YAM—1930.
(*see* TABLE VI)

Variety of yam with which grown.	Yield of newly harvested heads : means of 4 plots (lbs. per acre).	Maturing qualities of yam.	Yields of yam. (lbs. per acre).
With Labaco ...	882	Early	5,850
With Puno ...	787	Mid-early ...	8,415
With Dapam ...	712	Main-crop ...	6,885
With Zillambo ...	663	Late	7,605
With Peringa ...	582	Late	6,810
Mean	726 lbs. per acre.		

The millet used in this experiment was the local late species and is normally grown interplanted with yam on certain soil types. It may also be grown with groundnuts or bambarra beans and is commonly grown on some soils as a pure stand. The yield of millet was highest when grown with the early maturing variety Labaco, lower with the mid-early variety Puno, still lower with the main-crop variety Dapam and lowest with the late maturing varieties Zillambo and Peringa. The differential yields, however, are not significant, since to comply with the recognised conditions the difference in yield must be greater than 327 lbs. per acre. Despite this, the trial provides strong evidence that the earlier the yam matures, the larger will be the yield of the interplanted millet. In this experiment the mean yield of millet, 726 lbs. per acre of newly-harvested heads, compares favourably with crops grown as pure stands in past years.

GROUNDNUT SPACING TRIAL—1930.
(*see* TABLE VII.)

Spacing.	Yield of newly harvested nuts in shell. Means of 12 plots (lbs. per acre).
" Close " (6" x 6" on 6 ft beds)	831
" Medium " (6" x 1 ft. on 6 ft. beds) ...	564
" Wide " (1 ft x 2 ft on 6 ft. beds) ...	354

The seed used in this experiment was from a local procumbent variety. Locally the crop is usually interplanted with maize, guinea-corn or millet : groundnuts are only very occasionally grown as a pure stand. The yields were highest with close spacing and lowest with wide spacing. The groundnuts planted closely yielded half as much again as those planted at the medium spacing, and more than twice as heavily as those planted widely ; these differences are statistically significant. The superiority of the medium spacing over the wide spacing is not quite significant, but, with the other results, helps the value of close spacing when the crop is grown as a pure stand.

D. FARMING SYSTEMS.

It is understood that any radical changes in farming practice to be recommended by the Department of Agriculture must be improvements on the local practice and must have been satisfactorily tested and proved over a number of years. The details of the trials below are given without attempts being made to draw deductions unless in the case of single point investigations.

Five Course Rotation.—Crops : Yam, Bengal beans, cotton, guinea-corn, maize and groundnut.

Three Course Rotation.—Crops : Yam, Bengal beans, maize and groundnut.

YIELDS IN LBS. PER ACRE.

Crop.	5 Course Rotation.		Remarks.
	1929.	1930.	
Yam	6,296	9,400	Freshly harvested tubers.
Cotton	158	328	Seed-cotton ; 1929, out of fallow ; 1930, after Bengal beans dug in during 1929.
Guinea-corn ...	596	830	Freshly harvested heads.
Maize	110	250	freshly harvested threshed grains.
Groundnut ...	(not grown)	670	Freshly harvested nuts in shell ; weight of dry unshelled nuts was 300 lbs.

Crop.	3 Course Rotation.		Remarks.
	1929.	1930.	
Yam	6,379	7,544	Freshly harvested tubers
Maize	213	700	Freshly harvested threshed grains.
Groundnut ...	(not grown)	748	Freshly harvested nuts in shell, weight of dry unshelled nuts was 330 lbs.

COVER CROP EXPERIMENT—1929.
(*see* Table VIII).

The object of this experiment was to find out whether Bengal beans could be established with maize, to discover the effect of the interplanted Bengal beans with a maize crop, and to determine the best time for such interplanting.

Treatment.	Yields of freshly harvested and threshed maize grain. (lbs. per acre).
"Control"— No Bengal beans	402
"Early" Bengal beans sown on same date as maize	266
"Late" Bengal beans sown when maize 2 ft to 2½ ft high	386

Sowing the Bengal beans on the same day as the maize was definitely detrimental to the maize, and resulted in a greatly reduced yield. When the Bengal beans were sown in maize 2 ft.-2½ ft. high, the maize crop was little inferior to that grown as a pure stand. The reduction in yield observed was not significant, and in addition, when six weeks had elapsed after the maize had been harvested, the cover crop that had been planted late appeared to the eye to be as thick as that planted early. In both the cover was excellent, but it must be borne in mind that the maize crop was short on the average, and gave a poor yield. In common with other plots of Bengal bean on the station which were allowed to seed, the cover died down shortly after the advent of the *harmattan* season.

A similar experiment with guinea-corn as the cereal crop was conducted.

Treatment.	Yield of freshly harvested heads. Mean of 4 plots (lbs. per acre).
"Control"— No Bengal beans	50
"Early" Bengal bean sown on same date as guinea-corn	173
"Late" Bengal beans sown when guinea-corn was 2 ft to 2½ ft high	302

The early sown Bengal beans almost smothered the guinea-corn, the stalks of the cereal were gradually pulled down and most of them did not produce heads. The late sown Bengal beans grew to the top of the guinea-corn stalks, but did not cover the ground; the effect was to decrease the yield of the guinea-corn by almost half.

An experiment to compare mixed and single cropping was laid down in 1929 with maize, groundnuts, and guinea-corn, and is described in the 1929 Year-Book, Paper No. XXI.

NATIVE SYSTEM OF CROPPING.

(*a*) *Soil.* —Sandy loam.

Crops.—Yams and interplanted millet (*see* Table IX).

Yields.—Yam (freshly harvested tubers including seed yams).	...	7,100 lbs. per acre.	
Millet (dry threshed grain)	...	435 ,,	,,
Estimated value of produce per acre	...	£7	0 1
Labour costs—per acre (excluding cost of headman)		5	6 4
No. of man-days of labour—per acre (excluding headman)		169	

In this trial a larger proportion of boy-labour was employed than in the trial following.

(*b*) *Soil.* —A silty soil with a tendency to waterlogging during part of the wet season.

Crops. —Early yam (Labaco variety), early planted maize, rice (*see* Table X).

Yields.—Yam (freshly harvested tubers including seed yams)		5,030 lbs. per acre.	
Maize (dry grain ; crop attacked by locusts and partly destroyed		54 ,,	,,
Rice (paddy)		286 ,,	,,
Estimated value of produce per acre	...	£6	19 8
Labour costs per acre (excluding cost of headman)		5	12 6
No. of man-days of labour per acre (excluding headman)		150	

Values of produce were calculated from Tamale market prices ruling at the time the various crops were harvested. Large variations in price throughout the year have been observed.

GREEN MANURE TRIALS—1930.

(*a*) On a sandy soil (Block 13). Duplicated experiment. System of layout—randomised block.

(*b*) On a silty soil (Block 52).

Treatments.	*Notes.*
Bengal bean	Sown 26th April, on 4 ft. ridges. Holes 1 ft. apart ; two seeds per hole. A satisfactory cover was obtained on both trials.
Calopogonium mucunoides ...	Sown 26th April, and resown on 9th May on 4 ft. ridges ; holes 8″ apart three to six seeds per hole. The plants were very much slower than Bengal beans but at the end of the rains had made a very good cover on both trials.
Crotalaria perrottetii	Sown 26th April, and resown on 9th May, on 2 ft. ridges, hole 8″ apart, three to six seeds per hole. The plants made poor growth and on Block 52 were almost a failure. On Block 13 better growth was obtained but only at the end of the rains was much progress made. Weeds were not smothered as in the Bengal bean plots and, to a lesser extent, in the *Calopogonium* plots.
Bush Fallow	A thick growth in both trials.
General Notes	Only one weeding was done on the green manure treatments, and heavy rains in May caused considerable damage to the plots.
	During 1931 food crops will be grown over the trials and the effect of the provisions green manuring measured and tested against the bush fallow treatment.

APPENDIX A.

A list of papers already published dealing with the work on Tamale Investigation Station :—

1. Local foodstuffs. 1928 Year-Book, Paper XXVII.
2. Minor industries. 1928 Year-Book, Paper XXXII.
3. Cotton results 1928–1930. 1928 Year-Book, Paper XXXV 1929 Year-Book, Papers XXXV and XXXVI.
4. Mixed Cropping. 1929 Year-Book, Paper XXI.
5. Special Investigations. 1928 Year-Book, Paper XXX.
   (*a*) Shea. 1929 Year-Book, Papers XXVIII and XXIX.
   (*b*) Field Technique and Soil Erosion Studies. 1929 Year-Book, Paper XV.

APPENDIX B.

Rainfall Table.

Tamale Investigational Station. Position. 660 feet above sea level, 280 miles from the sea.

Month.	Rainfall in 1929. Inches.	Number of wet days.	Rainfall in 1930. Inches.	Number of wet days.	Average rainfall for 21 years. Inches.
January	Nil	—	Nil	—	.03
February	0.53	3	0.78	1	.30
March	0.84	5	1.85	3	2.24
April	3.42	8	3.57	11	3.20
May	8.25	11	9.29	13	4.94
June	2.82	13	3.63	9	5.61
July	8.84	16	6.46	12	5.41
August	5.86	15	8.63	15	8.32
September ...	11.75	20	8.12	19	8.68
October	7.30	13	3.88	10	3.43
November ...	1.65	2	0.32	2	.75
December	—	—	0.89	1	.11
	51.26	106 days	47.42	96 days	43.02 inches

TABLE I.

Shea.—Trial with seed from 16 selected trees.

No. of block.—19.

Layout of Experiment.—Randomised block system. 15 blocks each containing 16 trees (one of each selection).

Dates of planting.—24th and 25th June, 1929.

Planting distance.—25 ft. x 25 ft.

No. of seeds per hole.—Two (nuts).

Date vacancies filled.—8/5/30 to 21/6/30.

SELECTIONS.

% stands visible on	T.1	T.2	T.3	10	15	E.	R.	D.2	5	9	12	D.	6	13	11	14
4–10–29 ..	94	94	94	81	75	69	69	56	56	56	56	50	44	31	25	25
4–10–29 ..	58 per cent.															
27–2–30 ..	49 per cent.															
7–5–30 ..	62 per cent.															
24–2–31 ..	82 per cent.															

During 1930, Tree No. 14 died, and seed was obtained from No. T3 to plant up in the places formerly occupied by seed from tree No. 14. It is apparent that during the dry season a percentage of the young shoots die down, and counts made fail to include them as living. During the rains a fresh shoot is sent up and this explains the apparent anomaly of a large percentage of stands counted on 7–5–30 when compared to the count made on 27–2–30. It was only after 7–5–30 that vacancies were filled.

The first three selections are situated on Tamale Station while the remainder are at Yendi. It is apparent from the germination count taken on 4–10–29, that the viability of the shea seed is quickly destroyed by exposure or storage.

TABLE II.

Yam Variety Yield Trial—1929.

(After Jerusalem Peas).

No. of block.—11.

Layout of experiment.—Randomised block system, each plot $\frac{1}{50}$th acre.

Date of planting.—16th March, 1929.

Planting distance.—Mounds 4′ x 5′.

Harvesting date.—6th December, 1929.

Variety.	Yield of freshly harvested tubers in lbs. per plot.				
	Block.				Mean.
	A.	B.	C.	D.	
Puno	176.5	177	205	225	195.9
Dapam	262	187	201	170.5	205.1
Zillambo	196	209	210	217	208.0
Peringa	191	214.5	147	201.5	188.5
Means	206.3	196.9	190.7	203.5	Mean of all 199.4

Varieties were not pure enough to warrant differences in yield being established. Plots were too small for this kind of crop to warrant statistical analysis.

TABLE III.

YAM—VARIETY YIELD TRIAL, AND INTERPLANTED MILLET TRIAL—1930. (OUT OF FALLOW.)

No. of block.—46.

Layout of experiment.—Randomised block system, each plot $\frac{1}{15}$th acre.

Dates of planting.—21st and 22nd January, 1930—Yam. 16th July, 1930—Millet.

Planting distance.—Mounds— 4′ × 5′.

Date of harvesting.—20th December, 1930—Yams. 24th December, 1930—Millet.

Variety.	Yields of freshly harvested tubers in lbs. per plot.				
	Blocks.				Mean.
	1.	2.	3.	4.	
Labaco	437	293	384	445	390
Puno	530	645	474	595	561
Dapam	443	490	534	360	457
Zillambo	471	487	395	675	507
Peringa	379	530	452	454	454
Means	452	489	448	506	Mean of all 474

ANALYSIS OF VARIANCE.

Variation.	Degrees of freedom.	Sum of the squares.	Variance
Between varieties	4	4 × 15,455 — 61,820	15,455
Within varieties	15	99,311	
Between blocks	3	5 × 1,461 — 7,305	
Random	12	92,006	7,667.1

Standard error of comparison of two variety means = 61.9
For P = .05 and n = 12, t = 2.179 ;
∴ Significant difference in yield—134.8 lbs.

TABLE IV.

RICE—VARIETY YIELD TRIAL—1929. (OUT OF FALLOW.)

No. of block.—8.

Layout of experiment.—Drill strip method, each plot $\frac{1}{10}$th acre

Planting material.—Two selections made in 1928
(1) Black-glumed.
(2) Yellow-glumed.

Date of planting.—14th June, 1929.

Planting Distance.—Rows 1′ apart with 6″ between the hills.

No. of seeds per hole.—Two.

No. of plot.	Yields of paddy in lbs. per plot.	
	Black.	Yellow.
1	70.5	75.0
2	68.0	70.0
3	49.0	74.0
4	55.5	41.0
5	45.0	42.0
6	33.5	46.5
7	45.0	49.5
8	43.5	54.5
9	60.0	63.5
Total	470.0	576.0
Mean	52.2	57.4

$S(x - \bar{x})^2 = 957$

$\bar{x} = 5.1$

$\frac{s}{\sqrt{n}} = 3.65$

$t = 1.39$

For $n = 8$, $P. = 0.2$

TABLE V.

MAIZE—COMBINED SPACING AND TIME PLANTING TRIAL—1929.
(AFTER COTTON IN 1928).

No. of block.—21.

Layout of experiment.—Randomised block system, each plot ¼ acre.

Dates of planting. —(1) "Medium-early" 14th May, 1929.
(2) "Late" 12th July, 1929.

Planting distance—2′ and 3′ etc.

YIELDS OF FRESHLY HARVESTED AND THRESHED GRAIN IN LBS. PER PLOT.

Block.	Treatment. "Early" 2 ft-	"Early" 3 ft.	"Late" 2 ft.	"Late" 3 ft.	Mean.
A	116	121	28	10	68.8
B	176	133	138	165	153.
C	231	82	83	29	106.2
D	169	146	29	14	89.5
Mean	173.0	120.5	69.5	54.5	Mean of all. 104.4

ANALYSIS OF VARIANCE.

Variation.	Degrees of freedom.	Sum of the squares.	Variance.	½ log 10 V.
Blocks	3	15,335		
Treatments, Early v Late	1	28,528	28,528	5.1293
2 ft v 3 ft	1	4,376	4,376	4.1920
Interaction	1	1,705	1,705	3.7206
Total Treatment ...	3	34,609	11,536	4.6715
Residual (error) ...	3x3 = 9	18,310	2,034	3.8089
Total	16–1 = 15	68,254		

z = .8726 ∴ Difference due to total treatment is significant.
Standard error of experiment = 45.1

INTERACTION BETWEEN TIME PLANTING AND SPACING.

Variance.	Sum of the squares.
Time Planting, Early v Late	28,258
Spacing 2 ft v 3 ft	4,376
Interaction	1,705
Total Treatment	34,609

The differential response (interaction) is clearly not significant.

Time of planting. For n = 9 and t = 3.7, P = less than 0.01 ; therefore significant difference.

Spacing. P = 0.1 to 0.2, therefore difference not significant.

TABLE VI.

Millet Grown Between Yam Mounds—1930. (Out of Fallow).

No. of block.—46.

Layout of experimeut.—Randomised block system, each plot 1/15th acre.

Date of planting.—14th July, 1930.

Planting distance.—Double row of plants between mounds ; rows 4′ apart.

No. of seeds per hole.—3–6 giving 2–4 plants per stand.

Variety of yam.	Yields of millet (freshly harvested heads) in lbs. per plot.				
	Block 1.	Block 2.	Block 3.	Block 4.	Means.
Labaco	40	44	100*	51	58.8
Puno	38	40	54	79	52.5
Dapam	34	52	46	58	47.5
Zillambo ...	39	37	41	60	44.2
Peringa ...	28	41	47	39	38.8
Means	35.8	42.8	57.6	57.4	Mean of all 48.4

* Wild Bamboo formerly present in this plot.

Analysis of Variance.

Variation.	Degrees of freedom.	Sum of the squares.
Within varieties ...	15	4,232
Between blocks ...	3	5 x 355 = 1,775
Random	12	2,457

Standard error of comparison of two variety means = 10.0.

For P = .05 and n = 12, t = 2.179 ;

: : Significant difference in yield = 21.8 lbs.

TABLE VII.

GROUNDNUTS—SPACING TRIAL—1930.
(GROWN IN SHEA TRIAL AREA).

No. of block.—5.

Layout of experiment.—Strip system, each plot 1/22nd acre.

Dates of planting.—16th to 22nd May.

Planting distance. —(*a*) 6″ × 6″ on 6 ft. beds.
(*b*) 6″ × 1 ft. on 6 ft. beds.
(*c*) 1′ × 2′ on 6 ft. beds.

No. of nuts per hole.—Two; thinned after to a single plant.

YIELD OF FRESH UNSHELLED NUTS IN LBS. PER PLOT.

Plot No.	Treatment.		
	A.	B.	C.
1	73	15.5	31.5
2	40	24.5	17
3	50	36	27.5
4	42	42	15
5	36.5	31	19.5
6	31	29	8.5
7	27	28.5	27.5
8	34.5	31	16
9	41.5	27	19
10	23.5	12	11
11	23.5	10	2
12	31	20	6.5
Mean ...	37.7	25.5	16.8

$\sigma_d = 11.73$

$\mathcal{E}_d = 3.4$

Treatment difference.	Significance.
A—B — 12.3 lbs.	Significant (3.6 times $\mathcal{E}_d$).
A—C — 21.0 lbs.	Significant (6.2 times $\mathcal{E}_d$).
B—C — 8.7 lbs.	Not significant (2. 5times $\mathcal{E}_d$).

In this case the test for significance lies in the ratio of the mean treatment difference to the standard error. A ratio of 3 : 1 is termed significant.

TABLE VIII.

No. of block.—10.

Layout of experiment.—Randomised block system, area of each plot $\frac{1}{6}$th acre.

Dates of planting.— 29th May 1929 — Maize.
29th May, 1929 —Bengal beans (first planting).
12th July, 1929 —(Second planting).

Planting distance.—On 4′ ridges, 2′ between stands of single plants—maize.

No. of seeds per hole.—Two; Bengal beans.

YIELD OF MAIZE (FRESH GRAIN) IN LBS. PER PLOT.

Treatment.	Blocks.				
	A.	B.	C.	D.	Mean.
Control	63	84	78	43	67.0
Early	40	56	60.5	21	44.4
Late	60	92	56.5	48.5	64.3
Mean	54.3	77.3	65.0	37.5	Mean of all 58.5

ANALYSIS OF VARIANCE.

Variance.	Degrees of freedom.	Sum of the squares.	Variance.	Log_{10} V	$\frac{1}{2}\text{Log}_{10}$ V
Between treatments	2	4 x 304.7 = 1218.80	609.40	2.7849	1.3925
Within treatments	9	3058.95			
Between b.ocks	3	3 x 875.58 = 2626.74			
Random	6	432.21	72.04	1.8575	0.9288

$z = 1.0677$

$n = 2$ and $n_2 = 6$ the difference due to treatment is therefore significant.

Standard error of comparison of two treatment means = 6.0.

When $n_2 = 6$ and $P = 0.05$, $t = 2.447$;

$\therefore$ Significant difference in yield = 14.682 lbs.

Where $P = .01$, significant difference in yield = 22.242 lbs.

Treatment difference.	Difference between yields.	Significance.
Control — " Late " ...	2.7 lbs.	Not significant.
Control — " Early " ...	22.6 lbs.	Significant (higher level)
" Late "— " Early " ...	19.9 lbs.	Significant (lower level.).

TABLE IX.

Native System A.

Type of soil.—Sandy.

Crops grown.—Yams and interplanted millet.

No. of block.—46.

Area of trial.—1½ acres.

Planting distance.—4 ft. between mounds; 5 ft. between contoured lines of mounds; made in November, 1929.

Date yams planted and capped.—21st–29th January, 1930.

Date millet planted.—16th July, 1930. Double row between lines of mounds; 4 ft. between hills.

No. of seeds per hole.—3–6; plants thinned to two and vacancies filled with thinnings.

Dates of harvesting.—20th December, 1930—millet.

24th December, 1930—yams.

LABOUR COSTS—NATIVE SYSTEM A.

Operation.	Costs calculated per acre. £ s. d.	Remarks.
Clearing and burning and making yam mounds	1 11 1	The area of the trial was covered with spear grass and cultivation costs are therefore high.
Planting seed yams	0 10 10	*Estimated value of crops per acre.*
Capping mounds and first hand weeding	0 13 1	*Yams.*—Saleable tubers 6,000 lbs. @ 0.2d. per lb. ... £5 0 0
Weeding and filling vacancies	1 1 8	2,200 seed yams @ 1s. per 100 ... 1 2 0
Cutting yam sticks and staking	0 17 6	*Millet.*—435 lbs. grain @ 0.5d. per lb. ... 0 18 1
Training yam vines including re-staking fallen sticks. ...	0 5 0	
Cultivation preparatory to sowing millet	0 4 2	
Sowing millet, thinning and transplanting	0 2 0	
Harvesting millet	0 8 2	
Harvesting yams	0 15 2	
Total labour costs	6 8 8	Estimated value of crops per acre £7 0 1

(Wages—boys 6d. men 9d. per day, headmen 1s. to 1s. 8d. per day).

No. of man-days per acre (excluding headmen) = 186 — 17 = 169.

Cost of headmen per acre £1 2 4

TABLE X.

Native System B.

Type of Soil.—Silty.

Crops grown.—Yams, maize and rice.

No. of block.—53.

Area of trial.—Two acres.

Planting distance.—4ft. between mounds ; 5 ft. between contoured lines of mounds made in November, 1929.

Date yams planted and capped—24th January to 1st February 1930.

Dates of planting.—Maize—21st March, 1930—single row on sides of lines of yam mounds. Replanted 22nd May, 1930.

Rice—19th June, 1930. Broadcasted between lines of yam mounds.

No. of seeds per hole.—two; Maize.

Dates of harvesting.—Maize—23rd August, 1930.

Rice—11th November, 1930.

Yams (large tubers) ($\frac{1}{3}$rd area) 21st July, 1930

Yams (large tubers) $\frac{1}{3}$rd area 13th–14th November, 1930.

Yams (seed yams) 13th–14th November, 1930.

TABLE X.

LABOUR COSTS—NATIVE SYSTEM B.

(Including Cost of Headmen).

Operation.	Costs calculated per acre. £ s. d.	Remarks.
Clearing and burning and making yam mounds	1 8 9	The main yam tubers were harvested over ⅓ rd of the area in July, and the total seed yams and remainder of large tubers in December.
Planting seed yams	0 8 7	
Capping mounds and first hand-weeding	0 14 10	
Weeding and filling vacancies	0 15 6	
Cutting yam sticks and staking	0 12 0	
Training yam vines and re-staking fallen sticks	0 5 9	
Sowing maize and filling vacancies	0 3 0	
Interplanting rice and preparatory cultivation	0 2 7	
Harvesting yams (large tubers and seed size)	1 1 0	
Harvesting and shelling maize	0 3 0	
Harvesting and threshing rice	0 4 10	
		Estimated value of crops from area (two acres).
		Maize.—107 lbs. @ 0.1d. per lb. £0 8 11
		Yam. —Early tubers 1,705 lbs. @ 0.4d. per lb. ... 2 16 10
		Late tubers 4,936 lbs. @ 0.25d. per lb. ... 5 2 10
		6,500 saleable seed yams @ 1s. per 100 ... 3 15 0
		Rice. —536 lbs. paddy @ 0.8d. per lb. ... 1 15 9
		£13 19 4
Total labour costs	£5 19 10	Estimated value per acre £6 19 8

(Wages—boys 6d. men 9d. per day, headmen 1s. to 1s. 8d.)

No. of man-days per acre (excluding headmen) 155—5 = 150.

Cost of headmen per acre £0 7 4

PAPER No. XXXIII.

WORK OF KPEVE INVESTIGATIONAL STATION, SEASON, 1930-31.

By H. K. HEWISON and C. W. J. LINE.

General.

During the season 1930–31 the work of development has been practically completed. Adequate bungalow accommodation has been provided, offices, stores and roads have been completed, and wells sunk for water supply.

Cacao.

Manurial and cultivation trials with cacao have continued and detailed records have been collected of the performances both of areas receiving special treatment and also of individual trees. Much information is being accumulated in connection with the investigation into the production of fruit by *Theobroma cacao*, involving daily records of flowering, flower-shedding, fruit-setting, fruit-development and loss. The correlation of these figures with data for environment may be expected to throw further light on the problems relating to the securing of high yields. Hybridisation and selfing of trees of outstanding merit have continued and progeny plots have been established during the year.

Fruit.

The suitability of the district for citrus cultivation is being examined, and, with this in view, a block of 16 acres of limes has been laid down. Green manurial trials are being carried out to test the value of cover crops for the citrus trees during their early years of growth.

Commercially desirable varieties of grape-fruit and oranges introduced from the West Indies, have made satisfactory progress,

Imported types of pine-apples and papaws have been established, and the stand of *Hydnocarpus anthelmintica* (the source of Chaulmugra oil for the treatment of leprosy), has made good progress.

Cotton.

The principal work has been in connection with the selection and production of the most desirable type of cotton for the district, and a considerable area has been under trial with the varieties Sonko and improved Ishan. The performance of the imported Ishan has been such as to justify the creation of special seed plots in the neighbouring districts.

Plots carrying the progeny of previous selections have been established. Rigorous selection has again been carried out, and plants possessing the most desirable characters selfed with a view to providing progeny plots for future work.

Foodstuffs.

With the export trade in foodstuffs in Togoland, an increased importance attaches to the work of selection of improved types and the importation of new varieties. Numerous strains of cassava, maize, yams, sweet potatoes, beans, peas, guinea corn, millet and rice have been introduced and subjected to tests as to their performance and productivity under local conditions.

A comprehensive collection of material suitable for green manures and cover crops has been made and it is now possible to lay out carefully considered trials to determine their relative values for use in general cultural practice in connection with the establishment of permanent crops.

Experiments.

With the exception of the cotton experiments, the following are the results of main experiments carried out during the year :—

CACAO—GENERAL.

Planted at 13′ × 13′	1913–14
Area	20 acres
Fruiting trees	3,964

Yields on record, expressed in lbs. dry cacao per acre are :—

TABLE I.

Year.	Jan-Dec. (Calendar year).	April-March. (Financial year).	Sept.-Aug. (Crop year).	Season.
1922	354	456	437	1922–23
1923	439	375	341	1923–24
1924	251	365	309	1924–25
1925	580	556	651	1925–26
1926	897	832	801	1926–27
1927	264	567	818	1927–28
1928	1,091	1,063	881	1928–29
1929	1,397	1,193	1,095	1929–30
1930	551	742	—	1930–31

The general yield of the cacao area on the Station was slightly less in 1930–31 than in the four previous seasons, but this is possibly due to seasonal variation.

STANDARD CACAO MANURIAL TRIAL

Object :—A trial laid down on the four Departmental Stations to ascertain the effect of applying artificial manures and mulch to fruiting trees.

Scheme :—Eight quarter-acre plots (A—H). A. B. C. and D. each comprising four rows of 16 trees, form one block, E. F. G. and H. comprising two rows of 32 trees form a second block. Full details of the experiment will be found in paper No. XIII of the 1929 Year-Book.

TABLE II.

Plot.	No. of trees.	Treatment.	Amount per plot.
A.	50	No. treatment	—
B.	51	Dried blood ... ... Sulphate of potash ...	1 cwt. ½ cwt.
C.	56	Basic slag. ... ... Sulphate of potash ...	2 cwt. ½ cwt.
D.	63	Dried blood ... ... Basic slag ... ... Sulphate of potash ...	1 cwt. 2 cwt. ½ cwt.
E.	53	Mulching only	6–7 tons.
F.	55	Dried blood ... ... Sulphate of potash ... Mulching	1 cwt. ½ cwt. 6–7 tons.
G.	54	Basic slag ... ... Sulphate of potash ... Mulching	2 cwt. ½ cwt. 6–7 tons.
H.	49	Dried blood ... ... Basic slag ... ... Sulphate of potash ... Mulching	1 cwt. 2 cwt. ½ cwt. 6–7 tons.

DATES OF APPLICATION.

Manures.	Mulch.
August 1926	November 1926
December 1927	January 1928
November 1928	March 1929
October 1929	December 1929
October 1930	November 1930

TABLE III.

Plot.	No. of trees.	Yield per plot in lbs. dry cacao. Crop Year, September—August. 1926–27.	1927–28.	1928–29.	1929–30.
A. ...	50	362 (2)	347 (1)	299 (4)	355 (1)
B. ...	51	370 (1)	325 (3)	354 (2)	349 (3)
C. ...	56	286 (4)	266 (4)	299 (3)	299 (6)
D. ...	63*	315 (3)	342 (2)	361 (1)	349 (2)
E. ...	53	231 (7)	191 (8)	160 (8)	234 (8)
F. ...	55	260 (5)	211 (7)	272 (5)	311 (5)
G. ...	54†	252 (6)	217 (6)	243 (7)	311 (4)
H. ...	49‡	186 (8)	222 (5)	245 (6)	281 (7)

Yield per tree in lbs. dry cacao.

Crop Year, September—August.

1926–27.	1927–28.	1928–29.	1929–30.
7.2 (2)	6.9 (1)	6.0 (2)	7.1 (1)
7.3 (1)	6.4 (2)	6.9 (1)	6.8 (2)
5.1 (3)	4.8 (4)	5.3 (4)	5.3 (5)
5.0 (4)	5.4 (3)	5.7 (3)	5.8 (3)
4.4 (7)	3.6 (8)	3.0 (8)	4.4 (6)
4.7 (5)	3.8 (7)	4.9 (6)	5.7 (4)
4.7 (5)	4.0 (6)	4.5 (7)	5.7 (4)
3.8 (8)	4.5 (5)	5.0 (5)	5.8 (3)

CACAO—MANURIAL AND MULCH TRIALS.

Object.—To ascertain the effect of artificial manures and mulching upon fruiting trees.

Arrangement.—Restricted randomisation with a non-experimental zone of a line of trees between any two plots. A plan of the thirty-six plots involved in these trials will be found in Bulletin No. 20 page 83.

Figures in brackets shew order of yield.

*59 for 11 months.

†53 from April, 1930.

‡48 from April, 1930.

Treatment.—There are six replications of six treatments. Treatments are as follows :—

"K" ... No treatment
"L" ... Forked and mulched
"M" ... Dried blood 16 lbs. per plot
"N" ... Sulphate of potash 4 lbs. per plot.
"O" ... Basic slag 32 lbs. per plot.
"P" ... Sulphate of potash and Basic slag. } 4 lbs. and 32 lbs. per plot.

For simplicity, each plot of nine trees is taken to be one-twenty-eighth of an acre. On this reckoning, the manures are applied at the following rates :—

Dried blood ... ... 4 cwts. per acre.
Sulphate of potash ... ... 1 cwt. per acre.
Basic slag ... ... 8 cwts. per acre.

TABLE IV.

TIME OF APPLICATION OF TREATMENTS.

New Manurial Trial.	No. of trees.	Treatment.	Treatment.	
			1st.	2nd.
K 6 plots ...	38	No treatment	—	—
L 6 plots ...	45	Forking	20/11/28	16–19/12/29
		Mulching	4/4/29	3–4/1/30
M 6 plots ...	39	Dried blood—16 lbs. per plot.	16–1–29	16/1/30
N 6 plots ...	42	Sulphate of potash 4 lbs. per plot.	16/1/29	16/1/30
O 6 plots ...	42	Basic slag—32 lbs. per plot	16/1/29	16/1/30
P 6 plots ...	40	Sulphate of potash 4 lbs. per plot. Basic slag—32 lbs. per plot.	16/1/30	16/1/30

Yields.—To be recorded individually for each central or "key" tree and collectively for the nine trees comprising the plot

The data collected are :—

(*a*) Number of pods picked.
(*b*) Weight of pods picked.
(*c*) Wet weight of beans extracted from the pods.
(*d*) Dry weight of cacao produced.

TABLE V.

YIELDS: IN LBS. DRY CACAO. CROP YEAR 1929–30.

Plot.	No. of trees.	Key trees.	Total yield from similarly treated plots.	Average yield of individual key trees.	Yield per tree.
		Lbs. ozs.	Lbs. ozs.	Lbs. ozs.	Lbs. ozs.
K	38	34 9	264 10	8 10	6 15
L	45	48 14	272 10	9 12	6 1
M	39	32 14	318 14	6 9	8 3
N	42	23 5	238 6	4 10	5 10
O	42	23 11	286 6	4 12	6 13
P	40	37 2	287 2	7 7	7 3
	246	200 7	1,668 0	6 14	6 12

CACAO FORK—MULCH TRIALS.

Object.—To ascertain the effect of mulching and deep forking on fruiting cacao.

Arrangement.—The plan of these plots will be found in Bulletin No. 20, page 84. Restricted randomisation was adopted in laying out the area with a non-experimental line of trees between any two plots.

Treatment:—

Plots marked "A" ... No treatment.
Plots marked "B" ... Mulched.
Plots marked "C" ... Forked.
Plots marked "D" ... Forked and mulched.

TABLE VI.

TIME OF APPLICATION OF TREATMENTS.

Fork and Mulch Area. 16 Plots.	No. of trees.	Treatment.	Treatment.		
			1st.	2nd.	3rd.
A ...	18	Nil ...	—	—	—
B ...	26	Mulching...	3–11–1928	9–11–12–1929	25–11–30
C ...	29	Forking ...	21–8–1928	1–9–8–1929	20–23–10–30
D ...	31	Forking and Mulching...	21–8–1928 3–11–1928	1–9–8–1929 9–11–12–1929	20–23–10–30 25–11–30

Yields.

Yields are recorded individually for each of the central or "key" trees and collectively for the nine trees comprising a plot. The data collected are:—

(*a*) Number of pods.
(*b*) Weight of pods.
(*c*) Wet weight of extracted beans.
(*d*) Dry weight of resultant cacao.

TABLE VII.

YIELDS: CROP YEAR 1929–30 IN LBS. DRY CACAO.

Plot.	Key trees.		Total yield for treatment.		Average yield key trees.		Average yield per tree.	
	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
A ...	1	8	89	8	1	8	4	15
B ...	24	9	145	9	6	2	5	9
C ...	25	7	112	7	6	6	3	14
D ...	24	0	169	0	6	0	5	7
	75	8	516	8	—		—	

EFFECT OF OIL PALM SHADE ON CACAO YIELDS

Object.

A trial commenced during 1929 to ascertain the effect on the yield of cacao trees of the presence of oil palms affording shade.

Arrangement.

Two plots of equal area carrying cacao planted in 1913–14 at a spacing 13′ × 13′, one plot being free of oil palms and the second plot carrying palms as in the following diagram :—

TABLE VIII.

Unshaded						Shaded.					
v	v	v							v*	x	v
v	x	v	v	v				x	x*	v*	v*
x	v	v	v	v	x	v	x	x	x	x	x*
x	x	v	x	v	v	x	x	v	v*	x*	v*
x	x	x	x	x	v	v	x*	x	x*	x	x*
x	x	v	x	v	v	v*	x	x	x	x	x*
x	x	x	v	v	x	x	x	x*	*	x	x*
x	x	x	x	x	x	v	x	x	v	x*	v
x	x	x	x	x	x	v	x*	x*	v	x*	v*
x	x	x	x	x	x	x	v	v	x*	x	x
x	x	x	x	x	x	v*	x*	x	v	v*	v
x	x	x	x	x	x	v*	x	x	v	x	x

x — Fruiting trees 48 42
v — Vacancies 20 25
* — Oil palms nil 26

The yields obtained from the respective areas are as follows :—

TABLE IX.

EFFECT OF OIL PALM SHADE UPON THE FRUITING OF CACAO. YIELDS: 1930–31.

Area not shaded by Palms.

Month.	No. of pods picked.	No. of pods fermented.	Weight of pods.	Weight of wet beans.		Weight of dry cacao.		Average pod weight.	Average weight wet beans per pod.	Pods per lb. dry cacao.
			lbs.	lbs.	ozs.	lbs.	ozs.	ozs.	ozs.	
1930.										
April	83	70	31	13	6	5	9	7	3.1	12.6
May	103	80	40.5	10	6	4	14	8	2.1	16.4
June	26	25	16	5	3	2	0	10	3.3	12.5
July	29	28	18.5	6	11	2	3	10	3.8	12.8
August	73	73	57.75	16	4	5	13	12	3.5	12.5
September ...	183	174	162.25	40	12	16	5	15	3.7	10.7
October	293	277	244.25	62	8	24	10	14	3.6	11.2
November	973	953	818	188	4	78	9	14	3.1	12.1
December	1,063	1,015	917.5	190	8	83	9	14.5	3 0	12.1
1931.										
January	418	391	296.0	75	14	33	2	12.1	3.1	11.8
February	262	220	159.5	26	0	11	10.9	11.6	1.9	18 8
March	202	162	120.37	23	0	10	13.3	11.9	2.3	14.9
Total ...	3,708	3,468	2881.62	658	12	279	2 2	—	—	—

Area shaded by Palms.

Month.	No. of pods picked.	No. of pods fermented.	Weight of pods.	Weight of wet beans.		Weight of dry cacao.		Average weight of pods.	Average weight of wet beans per pod.	Pods per lb. dry cacao.
1930.			lbs.	lbs.	ozs.	lbs.	ozs.	ozs.	ozs.	
April	—	—				—		—	—	—
May	—	—				—		—	—	—
June	—	—	No	yield during		—		—	—	—
July	—	—	April	to September.		—		—	—	—
August	—	—				—		—	—	—
September ...	—	—				—		—	—	—
October	36	30	25.75	5	14	2	6	14	3.1	12.6
November	43	38	28.00	8	6	3	7	12	3.5	11.2
December	96	79	61.75	15	12	6	13	12.5	3.2	11.6
1931										
January	117	107	84.00	23	6	10	3.7	12	3.5	10.4
February	69	52	32.80	6	12	3	0.5	10.1	2.1	16.9
March	40	30	20.12	5	0	2	4.3	10.7	2.7	13.4
Total ...	401	336	252.42	65	2	28	2.5	—	—	—

RICE.

During the course of the year 31 types of rice were received from the following sources :—

Ceylon	... 24 types.
Trinidad	... 3 types.
British Guiana	... 2 types.
Tamale	... 2 types.

Of the foregoing, 11 Ceylon types and one from Trinidad failed to reach maturity owing to the advent of the dry season. The varieties failing were :—

Ceylon—	P—5	Sudumawi ...	... 6—7 months crop.
	P—9	Sudumawi ...	... 6—7 months crop.
	P—10	Sudumawi ...	... 6—7 months crop.
	I—17	Sudumawi ...	... 6—7 months crop.
	B—11	Kalumawi ...	... 6—7 months crop.
	G—3	Mahamawi ...	... 6—7 months crop.
	b—13	Kurulutuduwi	... 6—7 months crop.
	k—7	Surasamba	... 6—7 months crop.
	—	Local Hatiel	... 6½ months crop.
	a—8	Podiwi ...	... 5½—6 months crop.
	—	Local Honderawala	5 months crop.

Trinidad—Jerahan (crop period not known).

Details of the seed weight sown, size of plots, dates of sowing flowering and fruiting, together with yields, for the remaining varieties, are set out in the Table below :—

TABLE X.

No.	Name.	Date sown.	Date flowered.	Date cropped.	Weight of seed planted.	Yield of paddy.		Equivalent yield of paddy. per acre.
					ozs.	lbs.	ozs.	lbs.
	British Guiana.							
1	Demerara Creole	8–7–30	25–10–30	17–12–30	4	13	8	1,350
2	Blue Stick	8–7–30	27–10–30	18–12–30	4	23	13	2,381
	Trinidad Vars.							
1	Creole	11–7–30	25–10–30	19–12–30	8	28	9	1,428
2	Hatiel	11–7–30	27–10–30	20–12–30	8	27	4	1,362
	Ceylon Vars.							
12	Icpy/15 Sudu Heenati	24–6–30	7–10–30	24–11–30	4	11	3	2,237
13	Icpy/19 Sudu Heenati	24–6–30	4–10–30	11–12–30	4	6	13	1,362
14	Hn. 15 Hinati	24–6–30	1–11–30	11–12–30	4	9	5	1,862
15	Hf. J. Sudu Heenati	24–6–30	7–10–30	28–11–30	4	9	0½	1,900
16	I b. 16 Illankalayan	24–6–30	1–11–30	26–11–30	4	13	2	2,625
17	— Ankittels	24–6–30	3–11–30	16–12–30	4	5	9	1,112
18	Mb. 27 Morungan	24–6–30	22–9–30	16–12–30	4	2	7¾	497
19	— Local Heenati	24–6–30	7–10–30	1–12–30	4	10	2	2,025
20	Ho. 33 Karuppu Chinati	24–6–30	22–9–30	27–11–30	4	5	0	1,000
21	Ho. 6 Karuppu Chinati	24–6–30	29–9–30	13–12–30	4	7	0	1,400
22	26,640 Kandimurungan	24–6–30	22–9–30	13–12–30	4	7	0	1,400
23	27,614 Sulai	24–6–30	6–10–30	25–11–30	4	13	4	2,650
24	Hk. 13 Kalu-Hinati	24–6–30	25–9–30	6–11–30	4	3	0	600
	Tamale Vars. (Main plot).				lbs. ozs.			
1	Tamale—white	26–7–30	13–10–30	25–11–30	15 12	201	2	1,810
2	Tamale—black	26–7–30	13–10–30	25–11–30	9 13	117	5	1,056

CASSAVA.

Cuttings from the specimens of cassava types received during 1929 from Ejura and Togoland were planted out in March, 1930, with a view to obtaining sufficient planting material for a yield trial during 1931. The types were planted at 5 feet intervals along rows 5 feet apart, each row containing 20 stands.

In July the leaves of certain plants were observed to be affected by mosaic, and counts were made to ascertain the extent of this virus infection. These counts were repeated at intervals, and the following table indicates the degree of infection at various stages :—

TABLE XI.

INFECTION OF CASSAVA BY MOSAIC.

Type.	No. of stands.	No. of stands infected.			
		1–8–30.	1–11–30.	1–2–31.	1–4–31.
Bankye Fufuo	20	4	15	18	20
Tarquah	20	4	15	20	20
Bankye Hene	20	5	11	15	17
Odiawo	20	6	15	18	19
Agbeli Gba	20	3	13	15	17
Calabar (Cameroon)	20	nil	nil	nil	nil
Dahomey	20	nil	1	15	17
Mampong (Black)	20	6	15	17	18
Pampro Gbeli	20	18	20	20	20
Akwako	20	17	20	20	20
Bede Kofi	20	20	20	20	20
Bankye Nkani	20	18	20	20	20

It will be noticed that all varieties except "Calabar" were heavily infected. Unfortunately this is not a popular variety and it is intended during the coming season to continue investigations with those plants of other varieties which have given indications of immunity under the conditions of 1930.

NATIVE FOOD FARM.

Great difficulty has always been experienced in obtaining from native farms accurate yields of their crops. To obtain this information an area of $\frac{1}{2}$ acre on the Station was planted by a farmer in the local manner. The farm consisted of yams, cassava, maize, coco-yams and cotton. The yams and cotton were interplanted as also were the cassava and maize.

TABLE XII.

Crop.	No. of stands.	Yield in lbs.	Yield per acre, lbs.	Remarks.
Yams	501*	2,615	9,040	*mounds.
Cassava ...	264	1,029	9,338	
Maize	654	307†	2.786	†dried grain.
Coco-yams ...	307	268	2,162	
Cotton ...	161	27‡	93	‡seed cotton.

YAM SEED TRIAL.

Object.—To ascertain the yields and returns obtained when various weights and types of planting material are used.

Variety used.—Togoland " Klewu."

Arrangement.—Eight rows, each containing 17 stands at 5 feet intervals.

Planting Material.

Row 1. Whole tubers, uncut, weighing 8 ozs. or under.

Row 2. Whole tubers, uncut, weighing over 8 ozs. but not more than 16 ozs.

Row 3. Whole tubers, uncut, weighing over 16 ozs. but not more than 24 ozs.

Row 4. Whole tubers, chosen by Overseers, weight range 1 lb. 10 ozs. to 2 lbs. 9 ozs.

Row 5. Large tubers, Ashanti practice, ends cut off for food : weight range 1 lb. 6 ozs. to 2 lbs.

Row 6. Pieces cut from tubers of Row 5 : weight range 6 ozs. to 15 ozs.

Row 7. Seed yams cut as customary : weight range 1 lb. 2 ozs. to 4 lbs. 0 ozs.

Row 8. Fingers cut from seed yams used in Row 7 : weight range 3½ to 11 ozs.

Planting Date—1st April, 1930.

TABLE XIII.

TABLE OF YIELDS

Row.	Total weight of seed in row.		Total weight of crop in row.		Proportion of yield to seed.
	lbs.	ozs.	lbs.	ozs.	
1	9	—	29	12½	2.31 : 1
2	14	15½	62	3	3.15 : 1
3	20	2½	110	12	4.49 : 1
4	25	5	124	2	2.51 : 1
5	31	11	111	5	2.51 : 1
6	12	2	15	0	0.24 : 1
7	37	13½	161	6	3.26 : 1
8	7	7½	45	2	5.04 : 1

TABLE XIV.

Rainfall Data.

Month.	1927.		1928.		1929.		1930.	
	Inches.	No. of wet days.	Inches.	No. of wet days.	Inches.	No. of wet days.	Inches.	No. of wet days.
January ...	—	—	1.85	2	0.32	2	1.77	1
February ...	—	—	3.04	2	2.44	7	2.24	5
March ...	4.31	7	4.38	11	7.71	15	3.27	9
April ...	4.44	10	3.69	15	3.91	13	3.81	8
May ...	5.33	17	2.23	11	6.01	17	5.05	15
June ...	5.91	16	10.19	16	6.66	18	7.45	18
July ...	5.10	10	3.32	12	4.47	13	3.53	11
August ...	0.52	6	5.62	11	12.90	14	3.27	11
September ...	9.99	18	9.96	17	2.40	22	9.39	11
October ...	9.56	20	6.72	21	1.55	11	7.10	16
November ...	2.11	7	0.34	3	4.58	7	2.13	7
December ...	2.53	6	2.32	5	0.20	1	0.42	4
Total ...	49.80	110	53.65	126	53.15	140	49.43	116

PAPER No. XXXIV.

RAINFALL CHART OF WEST AFRICA.

COMPILED IN HEAD OFFICE.

The Chart accompanying this paper was originally prepared in connection with a preliminary note on " Rainfall in West Africa " for the Conference of Empire Meteorologists but was not finished at the time.

AREA SELECTED.

The limits of the area were determined by those usually chosen in the West African maps going south from a line drawn from St. Louis in French Senegal to Lake Chad. This comprises the whole area usually alluded to as West Africa.

DESIGNATION OF STATIONS.

It was found convenient to divide the 338 stations, the records from which have been used to compile the Chart, into Zones corresponding to the Political Areas. Although this has led to some difficulty in tracing the position of stations in big areas such as the French Soudan, it is more convenient than any other. It was impossible to name every station on the map owing to lack of space, so that numbers corresponding to the positions in the list were given. Space in the Gold Coast is so limited that even then some numbers have had to be omitted but all the most important stations have been retained. In one area no records were available (viz. Portuguese Guinea) but the line of best fit was not difficult to trace. In Liberia only Monrovia has a station, but, from the general contour, the lines can be continued without much risk of large error.

PERIOD OF RECORD.

It is usual and desirable to plot a Chart of this kind from as large a number of stations as possible, from records of as many years as possible and over the same period of years. Unfortunately in the early days, stations in West Africa have had to be placed where white men were available to take the records and therefore the records from a great many interesting places would have been lost if one period suitable to the majority had been chosen. For instance, if the period for which the French records are available (viz. 1921–1926) had been chosen, a large number (one-third) of the Gold Coast stations and some from the other countries would have to be withdrawn as they were not operating during that period. This would have

reduced the value of the map from the point of view of those people who would like to know how the rainfall in their district compares with others and also would have left even larger gaps in our knowledge of West African rainfall than exist at present. In consequence every record that was available for whatever period was included so that, whereas some may be more accurate than others, each record is as complete as it can be made.

POINTS OF INTEREST.

Several interesting facts have appeared in the process of compilation. Firstly the fact is definitely shown that, wherever the coast is opposed to the line of direction of the south-west Monsoon, there is an area of heavy rainfall. Secondly a dry area occurs in the centre of the Ivory Coast. This point was somewhat startling until it was confirmed by reference to "Le Coton" by Henry Yves who shows that even cotton in this area requires irrigation.

CONCLUSION

The Department of Agriculture have to thank His Excellency the Governor-General of French West Africa, the Director and staff of the Air Ministry, Meteorological Office, Mr. H. Nicholas and the authors of the Nigerian Handbook for records used in compiling the map. Mr. I. Y. Asare, of the Division of Statistics and Surveys, deserves great credit for his drawing of the map.

TABLES OF MEAN ANNUAL RAINFALL.

ZONE I.—FRENCH SOUDAN. (MEANS OF SIX YEARS, 1921–26).

(*By the courtesy of the Governor-General, French West Africa.*)

No.	Station.	Mean annual rainfall in inches.	No.	Station.	Mean annual rainfall in inches.
1.	Ansongo	12.0	17.	Kolokani... ...	26.2
2.	Bafoulabe ...	37.4	18.	Koulikoro ...	36.5
3.	Bamako	39.0	19.	Koutiala ...	38.0
4.	Bamba	9.9	20.	Meneka	14.1
5.	Bandiagara ...	24.8	21.	Mopti	20.3
6.	Bongouni ...	47.0	22.	Nara	20.5
7.	Bourem	5.0	23.	Nema	6.8
8.	Djenne	31.2	24.	Niafunke... ...	14.8
9.	Douentza ...	16.9	25.	Nioro	24.6
10.	Gao	12.6	26.	San	29.1
11.	Goundam ...	8.6	27.	Satadougou ...	50.2
12.	Hombori ...	15.4	28.	Segou	25.3
13.	Kati	41.2	29.	Sikasso	57.5
14.	Kayes	20.6	30.	Timbouctou ...	7.5
15.	Kidal	3.5	31.	Toukoto	36.7
16.	Kita	39.4	32.	Yelimane ...	22.3

ZONE VII.—LIBERIA. (MEANS OF SIX YEARS, 1921–26).

(*By the courtesy of the Governor-General of French West Africa.*)

97.	Monrovia.	161.1

ZONE VIII.—IVORY COAST. (MEANS OF SIX YEARS, 1921–26).

(*By the courtesy of the Governor-General of French West Africa.*)

98.	Abengourou ...	52.4	111.	Grand Lahou ...	60.4
99.	Aboisso	65.4	112.	Guiglo	81.7
100.	Agboville ...	49.6	113.	Korogho ...	60.5
101.	Bondoukou ...	57.9	114.	Lame	61.2
102.	Bouafle	59.1	115.	Man	69.7
103.	Bouake	46.6	116.	Odienne	56.8
104.	Bouna	40.5	117.	Petit Alepe ...	83.9
105.	Boundiali ...	57.2	118.	Sassandra ...	60.4
106.	Dabakala ...	50.2	119.	Seguela	53.8
107.	Daloa	60.5	120.	Tabou	70.8
108.	Dimbokro ...	57.6	121.	Tai	79.1
109.	Gagnoa	48.3	122.	Tiassale	42.8
110.	Grand Bassam ...	38.3	123.	Toulepleu ...	71.9

ZONE IX.—GOLD COAST. (THE FIGURES IN BRACKETS INDICATE THE NUMBER OF YEARS ON WHICH THE MEANS ARE CALCULATED).

(From the Year-Book of the Dept. of Agriculture, Gold Coast.)

No.	Station.	Mean annual rainfall in inches.	No.	Station.	Mean annual rainfall in inches.
124.	Abomposo ...	67.55 (17)	171.	Inchaban ...	41.38 (1)
125.	Aburi	47.59 (39)	172.	Jemma	75.37 (1)
126.	Accra	27.63 (43)	173.	Juaso	65.42 (14)
127.	Achimota ...	27.15 (5)	174.	Kajebi	68.71 (1)
128.	Ada	32.05 (7)	175.	Keta	27.67 (24)
129.	Adeja	70.65 (1)	176.	Kete Krachi ...	55.25 (17)
130.	Adubrim ...	68.46 (3)	177.	Kibi	63.99 (17)
131.	Agona	65.95 (4)	178.	Kintampo ...	70.59 (15)
132.	Ajua	45.21 (10)	179.	Kodia-Kese ...	67.23 (4)
133.	Akpafu	73.60 (1)	180.	Koforidua ...	52.09 (8)
134.	Akropong ...	39.69 (3)	181.	Kpandu	52.13 (10)
135.	Akuse	41.22 (15)	182.	Kpetsu	52.38 (4)
136.	Akwantambra ...	60.00 —	183.	Kpeve	52.20 (3)
137.	Amedjofe ...	72.26 (1)	184.	Kumasi	58.49 (23)
138.	Angu	53.45 (4)	185.	Labadi	25.17 (7)
139.	Anyinam... ...	65.80 (22)	186.	Labo-Labo ...	50.81 (8)
140.	Asamankese ...	59.58 (7)	187.	Lawra	49.06 (4)
141.	Asromaso ...	54.30 (3)	188.	Mampong ...	56.94 (4)
142.	Asuansi	49.59 (21)	189.	Mansu	69.82 (16)
143.	Atakrom ...	69.69 (5)	190.	Mpayo	68.28 (1)
144.	Atwabo	86.67 (3)	191.	Mpenasa ...	62.22 (5)
145.	Axim	76.69 (15)	192.	Mpraeso	68.54 (12)
146.	Ayinasu	55.17 (7)	193.	Navrongo ...	40.02 (4)
147.	Bawku	39.30 (3)	194.	Nkawkaw ...	64.58 (4)
148.	Begoro	69.77 (8)	195.	Nkwatia	65.00 (10)
149.	Bekwai	62.70 (16)	196.	Nsawam	44.86 (4)
150.	Birrimsu ...	70.45 (13)	197.	Obuasi	62.03 (4)
151.	Bole	48.52 (2)	198.	Oda	60.17 (15)
152.	Botoe	45.01 (1)	199.	Odumase... ...	38.11 (5)
153.	Bunso	67.08 (9)	200.	Otikrom	62.19 (4)
154.	Butre	53.53 (9)	201.	Otrokpe	45.56 (1)
155.	Cape Coast ...	38.19 (7)	202.	Peki Blengo ...	52.09 (13)
156.	Dafo	55.27 (1)	203.	Salaga	51.19 (15)
157.	Dentin	79.22 (2)	204.	Saltpond ...	32.14 (15)
158.	Djoje	41.60 (1)	205.	Sekondi	40.61 (26)
159.	Dunkwa	57.44 (15)	206.	Senchi	40.00 —
160.	Effiduase... ...	65.95 (3)	207.	Siwum	65.16 (8)
161.	Ejisu	62.17 (4)	208.	Suku-Suku ...	70.00 —
162.	Ejura	57.54 (14)	209.	Sunyani	59.57 (15)
163.	Esuaso	82.33 (4)	210.	Tafo	63.05 (4)
164.	Gambaga ...	42.99 (5)	211.	Tamale	42.55 (20)
165.	Goaso	51.23 (6)	212.	Tarkwa	68.15 (26)
166.	Half Assini ...	76.58 (8)	213.	Wa	47.00 (13)
167.	Hemang	67.08 (10)	214.	Wenchi	55.69 (8)
168.	Ho	54.83 (8)	215.	Wiawso	56.99 (12)
169.	Honuta	69.60 (1)	216.	Winneba ...	28.61 (8)
170.	Imprim	68.96 (4)	217.	Yendi	52.11 (8)
			218.	Zuarungu ...	43.34 (12)

ZONE X.—TOGOLAND. (THE FIGURES IN BRACKETS INDICATE THE NUMBER OF YEARS ON WHICH THE MEANS ARE CALCULATED).

(From German records extracted by H. Nicholas.)

219.	Anecho	31. 5	(5)	227.	Misahohe ...	65.38	(9)
220.	Asahun	45.16	(6)	228.	Nuatja	39.00	(7)
221.	Atakpame ...	53.46	(9)	229.	Nyangbo ...	56.26	(8)
222.	Bassari	51.20	—	230.	Sansane-Mangu	42.20	—
223.	Bismarkburg ...	54.70	(5)	231.	Sokode	52.03	(9)
224.	Jasikan	53.57	(6)	232.	Solo	43.80	(9)
225.	Kpalime	58.37	(6)	233.	Tafi	55.49	(9)
226.	Lome	31. 7	(6)	234.	Wurupong ...	54.02	(1)

ZONE XI.—HAUTE VOLTA. (MEANS OF SIX YEARS, 1921–26).

(By the courtesy of the Governor-General of French West Africa.)

235.	Banfora	49.9	244.	Kaya	26.2
236.	Bobo Douliasso	36.4	245.	Koudougou ...	35.7
237.	Boromo	38.1	246.	Koupela	31.1
238.	Diebougou ...	41.4	247.	Leo	39.7
239.	Dedougou ...	35.9	248.	Ouatigouya ...	27.8
240.	Dori	17.2	249.	Ougadaugo ...	32.7
241.	Fada N'Gourma	31.1	250.	Say	23.1
242.	Gaoua	56.5	251.	Tenkodogo ...	34.9
243.	Hounde	34.5	252.	Tougan	24.0

ZONE XII.—DAHOMEY. (MEANS OF SIX YEARS, 1921–26).

(By the courtesy of the Governor-General of French West Africa.)

253.	Abomey	40.0	266.	Kandi	42.8
254.	Abomey-Calavi ...	33.4	267.	Natitingou ...	50.7
256.	Adjahon	44.8	268.	Nikki	50.4
257.	Allada	42.3	269.	Ouidah	45.7
258.	Athieme	36.8	270.	Parahowe ...	41.5
259.	Bimbereke ...	42.9	271.	Parakou	51.1
260.	Bopa	31.9	272.	Pobe	40.5
261.	Boukombe ...	48.7	273.	Porto Novo ...	53.4
262.	Cotonou	78.5	274.	Savalou	46.7
263.	Djougou	54.6	275.	Save	83.7
264.	Grand Popo ...	42.5	276.	Zagnanado ...	39.7
265.	Guenne	37.3			

ZONE XIII.—NIGERIA. (THE FIGURES IN BRACKETS INDICATE THE NUMBER OF YEARS ON WHICH THE MEANS ARE CALCULATED).

(*Figures from the Nigerian Handbook.*)

277.	Abakaliki ...	82.6 (16)	303.	Katsina	29.4 (7)
278.	Abeokuta ...	49.6 (22)	304.	Keffi	48.6 (11)
279.	Afikpo	78.1 (24)	305.	Kontagora ...	52.4 (13)
280.	Agbor	76.8 (17)	306.	Kumba	86.9 (2)
281.	Agege	52.6 (14)	307.	Lagos	71.6 (28)
282.	Ankpa	55.7 (17)	308.	Lokoja	52.2 (27)
283.	Asaba	64.7 (22)	309.	Makurdi	50.8 (3)
284.	Bamenda ...	109.5 (7)	310.	Maiduguri ...	24.9 (20)
285.	Bauchi	50.7 (20)	311.	Minna	57.5 (15)
286.	Benin City ...	79.8 (23)	312.	Ogbomosho ...	50.5 (20)
287.	Birnin Kebbi ...	32.4 (17)	313.	Offa	51.9 (16)
288.	Brass	154.7 (19)	314.	Ogoja	80.3 (5)
289.	Calabar	110.1 (27)	315.	Olokemeji ...	51.4 (27)
290.	Debundscha ...	298.7 (3)	316.	Ondo	60.9 (28)
291.	Degema	93.9 (22)	317.	Opobo	140.6 (22)
292.	Ebute Metta ...	65.8 (23)	318.	Owerri	99.1 (24)
293.	Enugu	71.7 (13)	319.	Oyo	48.3 (23)
294.	Forcados ...	147.4 (23)	320.	Port Harcourt ...	97.6 (15)
295.	Hadeija	23.2 (11)	321.	Sapele	99.0 (25)
296.	Ibadan	51.8 (24)	322.	Sokoto	27.8 (24)
297.	Ibi	46.9 (20)	323.	Victoria	115.2 (7)
298.	Ikot-Ekpene ...	97.1 (22)	324.	Warri	109.4 (22)
299.	Ilorin	52.3 (24)	325.	Yola	39.9 (25)
300.	Jos	58.0 (8)	326.	Zaria	47.1 (24)
301.	Kaduna	53.9 (16)	327.	Zungeru	48.6 (26)
302.	Kano	35.7 (24)			

ZONE XIV.—CAMEROONS. (THE FIGURES IN BRACKETS INDICATE THE NUMBER OF YEARS ON WHICH THE MEANS ARE CALCULATED).

(*Frm the Meteorological Office records.*)

328.	Buea	105.7 (4)	330.	Yaunde	60.8 (6)
329.	Duala	155.6 (17)			

ZONE XV.—FRENCH NIGER. (MEANS OF SIX YEARS, 1921–26).

(*By the courtesy of the Governor-General of French West Africa.*)

331.	Agadez	5.0	335.	Niamey	23.3
332.	Blima	.71	336.	Tahoua	12.8
333.	Dogoudoutchi ...	23.6	337.	Tillabery ...	18.0
334.	N'guimi	7.9	338.	Zinder	17.6

PAPER No. XXXV.

METEOROLOGICAL RECORDS FOR 1930.

COMPILED BY

THE METEOROLOGICAL DIVISION.

The records show that conditions during 1930 were normal with no outstanding features.

Stations.

A new meteorological station has been opened at Esiama and new rainfall stations at Abakrampa and Jumapo. The rainfall station at Labadi has been closed.

Rainfall Records.

The highest monthly figures recorded during the year were 27.81 inches at Axim, 26.60 inches at Half Assini, and 22.42 inches at Atwabo—all in June. The heaviest rainfall during twenty-four hours was recorded at Honuta on June 5th when 9.27 inches fell. Other exceptionally high figures were 6.75 inches at Axim on the 24th June and 6.37 inches at Aburi on the 18th May.

Records for the year are given in Table IV. The attached rainfall map shows the mean annual distribution of rainfall throughout the colony.

Temperature Records.

The highest and lowest shade temperatures, 105.2° and 55°, were recorded on February 21st at Tamale and on July 5th at Begoro, respectively. The highest temperature in the sun, 174°, was reached at Kintampo on March 4th.

The monthly maximum, minimum and mean temperatures for each station are given in Table II.

Relative Humidity.

Relative humidity records show little variation from 1929. Mean monthly figures for all stations are given in Table III.

TABLE I.

Stations Arranged in Order of Degrees of Wetness.

Inches of Rain × number of Rainy Days.

100

1929		1930
—	146	Anyinam
Anyinam	142	—
—	133	Tarkwa
Kibi	131	—
—	128	Axim
—	127	Abomposu
—	126	Atwabo
Bunso	116	—
—	115	Mprim
Atwabo	114	—
—	111	Dadiasu
Mpraeso	109	—
Abomposu	108	—
Amedjofe	105	—
—	102	Mpraeso
Kete Krachi	99	—
Mprim	98	—
Tarkwa	96	—
Jemma	94	—
Nkawkaw	93	Juaso
Honuta	92	—
Juaso	90	—
Asamankese, Effiduasi	89	—
—	88	Amedjofe
Mpayo	87	Nkawkaw
Dunkwa, Ejisu, Oda	86	—
Begoro, Mansu, Agona	84	—
—	83	Aburi, Koforidua
Half Assini, Kajebi	82	Honuta
Akpafu	80	—
—	79	Dunkwa
—	78	*Wiawso*
Tafo	77	Mansu, Agona
Dafo	76	—
Dadiasu	75	Mpayo
Koforidua, Kpeve, Kumasi	74	Kintampo
—	73	Goaso
Dentin	71	Kibi, Jemma
Bekwai	70	Oda, Half Assini
—	69	Mampong (Ashanti)
—	68	Asamankese, Begoro
—	67	Kete Krachi
—	66	Dafo
Kpandu	64	Bekwai
Kintampo, Angu	63	Butre, Kajebi
Wenchi, Asromaso, Asuansi	62	—
Butre (Seysie)	61	Asromaso, Bunso, Dentin
Axim, Kodia-Kese	60	Asuansi, Effiduasi
Esuasu	59	—
Mpenasa	57	Esuasu, Kpandu, Kpeve
Mampong (Ashanti), Aburi	56	Kumasi
Tamale	55	Tafo
—	54	*Enchi*
—	53	Ejisu
Ejura	52	—
Akropong (Ashanti)	51	—
Akropong (Akwapim), Lawra	50	Angu, Otikrom
Wa	49	Ejura, Tamale

[P.T.O.]

TABLE I—*continued.*

1929		1930
—	48	Ho
Salaga	46	Lawra
Sunyani, Ho	44	Ajua, Wenchi
Botoe, Otikrom, Navrongo, Goaso	43	Akpafu
—	41	Botoe, Kodia-Kese, Sunyani
Sekondi	39	—
Yendi	38	—
—	36	Salaga, *Takoradi*
—	35	Mpenasa, Zuarungu
—	34	Navrongo
Accra, Odumase, Bawku, Ajua	33	Otrokpe
Bole, Zuarungu	31	Sekondi, Wa
	30	Odumase
—	29	Akropong (Ashanti)
—	28	Akropong (Akwapim), Nsawam
Djoje	27	—
—	26	Bole
Akuse	25	—
Otrokpe	24	Gambaga
Keta, Winneba	23	Cape Coast, Yendi
Achimota, Saltpond	22	Achimota, Djoje
—	21	Akuse
—	19	Accra, Bawku
Labadi	18	Keta
Nsawam	17	—
Cape Coast	16	Winneba
—	12	Saltpond
Gambaga	11	—

TABLE II.

Temperature Records for the Year ending 31st December, 1930.

Month.	Aburi.			Accra.			Achimota.			Akuse.			Asuansi.			Atwabo.			Axim.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.		Mean.	Max.	Min.	Mean.
January ...	88.6	71.3	79.9	90.4	75.2	82.8	87.7	71.9	79.8	96.0	71.2	83.6	86.6	69.3	77.9	86.1	73.0	79.5	86.0	73.3	79.6
February ...	90.5	72.2	81.3	92.5	78.1	85.3	90.5	71.2	80.8	99.1	74.2	86.	90.0	70.4	80.2	87.9	73.3	80.6	85.3	74.5	79.9
March	87.4	71.3	79.3	91.7	79.5	85.6	90.7	70.9	80.8	98.5	75.2	86.8	89.3	71.1	80.2	90.6	73.0	81.6	85.3	74.5	79.9
April	87.2	71.3	81.2	91.8	77.8	84.8	89.6	73.3	81.4	96.4	73.8	85.1	89.4	70.6	80.0	88.6	73.2	80.9	84.6	71.2	77.
May	85.8	70.7	78.2	91.4	79.1	85.2	82.8	73.8	78.3	93.7	74.1	83.9	87.4	70.3	78.8	86.4	74.2	80.3	83.9	73.9	78.9
June	81.2	69.5	75.3	87.0	75.5	81.2	82.8	72.4	77.6	90.4	72.9	81.6	82.3	70.2	76.2	83.1	73.8	78.4	84.4	72.7	78.5
July	79.1	68.0	73.5	85.1	75.0	80.0	80.0	71.1	75.5	86.7	71.5	79.1	80.4	68.7	74.5	84.1	73.6	78.8	85.6	73.9	84.7
August ...	78.8	67.0	72.9	83.4	73.0	78.2	80.0	70.2	75.1	89.1	71.4	80.2	78.5	68.6	73.5	81.3	71.6	76.4	84.4	73.9	79.1
September ...	80.6	68.2	74.4	83.3	73.0	78.1	81.6	71.2	76.4	91.3	72.6	81.9	81.0	70.7	75.8	82.4	73.0	77.7	85.0	72.0	78.5
October ...	82.5	69.6	76.0	84.5	74.1	79.3	83.6	72.1	77.8	91.1	72.5	81.8	85.7	71.5	78.6	83.7	73.6	83.6	85.8	69.8	77.8
November ...	85.3	70.9	78.1	89.3	76.7	83.0	88.1	73.3	80.7	95.3	71.9	83.6	87.0	70.0	78.5	86.5	74.1	80.3	86.8	69.0	77.9
December ...	86.0	71.7	78.8	89.6	77.3	83.4	87.8	73.7	80.7	96.4	73.0	84.7	86.9	71.4	79.1	86.6	75.0	80.8	87.5	68.5	78.0
Mean	84.4	70.1	77.2	88.3	76.2	82.2	85.4	72.0	78.7	93.6	72.9	83.2	85.6	70.2	77.7	85.6	73.4	79.5	85.3	72.2	78.7

TABLE II—*continued.*

TEMPERATURE RECORDS FOR THE YEAR ENDING 31ST DECEMBER, 1930.

Month.	Begoro.			Cape Coast.			Esiama.			Keta.			Kintampo.			Kpeve.			Kumasi.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
January ...	87.0	62.4	74.7	84.9	73.7	79.3	—	—	—	88.7	77.0	82.8	94.2	71.1	82.6	91.7	70.1	80.9	89.7	65.9	77.8
February ...	87.2	65.3	76.2	86.2	77.7	81.9	—	—	—	81.3	77.1	76.2	97.9	75.0	86.4	95.6	74.4	85.0	92.7	68.3	80.5
March	89.1	67.9	78.5	86.6	74.7	80.6	89.3	73.5	81.4	89.2	76.9	83.0	95.9	70.9	83.4	94.3	74.6	84.4	91.5	70.2	81.3
April	86.8	68.0	77.4	85.6	77.2	81.4	87.5	71.9	79.7	90.3	78.0	84.1	93.2	71.7	82.4	93.2	72.8	83.0	91.8	70.8	81.8
May	85.5	68.9	77.2	85.9	74.4	80.1	86.3	73.2	79.7	89.6	78.1	83.8	87.5	68.8	78.1	92.3	72.6	82.4	87.4	72.2	79.8
June	84.7	67.2	76.4	82.1	77.4	79.7	83.8	73.3	78.5	88.6	78.0	83.3	90.4	68.6	84.5	88.4	70.8	79.6	87.1	71.0	79.0
July	80.6	66.5	73.5	80.5	69.3	79.9	82.1	71.8	76.9	88.8	78.2	83.5	86.3	65.7	76.0	85.8	70.9	83.3	83.4	69.9	76.6
August ...	81.5	66.4	73.9	79.0	69.3	74.1	80.6	70.7	75.6	88.5	77.2	82.8	81.4	67.9	74.6	85.3	70.3	77.8	81.8	69.0	75.4
September ...	85.4	73.1	79.2	80.7	70.4	75.5	81.6	72.5	77.0	87.9	77.9	82.9	85.2	67.9	76.5	87.9	71.1	79.5	84.3	70.2	77.2
October ...	85.0	72.5	78.7	82.3	71.8	77.0	84.0	72.5	78.2	88.3	76.4	82.3	89.1	68.0	78.5	89.7	71.2	80.4	87.5	71.3	79.4
November ...	89.8	77.6	83.7	85.9	72.8	79.3	87.2	72.1	79.6	89.5	78.3	83.9	94.2	66.4	80.3	91.9	71.5	81.7	90.8	70.3	80.5
December ...	88.9	77.6	83.2	85.9	73.5	79.7	87.4	72.8	80.1	89.2	77.4	83.3	94.2	67.8	81.0	93.9	70.2	82.0	90.2	70.5	80.3
Mean	85.9	69.4	77.6	83.8	73.5	78.6	84.9	72.4	78.6	88.4	77.5	82.9	90.7	69.1	79.9	90.8	71.7	81.2	81.1	69.9	75.5

TABLE II—*continued.*

TEMPERATURE RECORDS FOR THE YEAR ENDING 31ST DECEMBER 1930,

Month.	Sekondi.			Takoradi.			Tamale.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
January	88.2	73.8	81.0	91.9	72.6	82.2	96.9	65.3	81.1
February	90.0	74.9	82.4	92.6	72.8	82.7	101.2	71.9	86.5
March	90.0	75.8	82.9	92.9	73.2	83.0	100.3	76.1	88.2
April	88.4	75.2	81.8	92.0	74.3	83.1	98.3	68.6	83.4
May	87.0	74.8	80.9	91.2	74.1	82.6	93.7	73.6	88.6
June	83.9	73.9	78.9	86.0	73.8	79.9	90.4	72.2	81.3
July	83.0	72.5	77.7	87.0	70.5	78.7	87.1	70.7	78.9
August	80.5	71.4	75.9	83.7	68.2	75.9	86.0	70.6	78.3
September	83.3	73.3	78.3	85.1	68.6	76.8	88.5	69.9	79.2
October	85.6	73.7	79.6	87.3	68.0	77.6	91.7	70.0	80.8
November	88.1	74.0	81.0	92.2	66.0	79.9	95.7	67.3	81.5
December	89.2	75.7	82.4	92.7	63.1	77.9	96.7	65.1	80.9
Mean	86.4	74.0	80.2	89.5	70.4	79.9	93.8	70.1	81.9

TABLE III.

Relative Humidity 1930.

Month.	Aburi.	Accra.	Achimota.	Akuse.	Asuansi.	Atwabo.	Axim.	Begoro.	Cape Coast.	Esiama.	Keta.	Kintampo.	Kpeve.	Kumasi.	Sekondi.	Takoradi.	Tamale.
January	80.1	75.8	78.8	76.8	89.1	88.4	88.3	85.4	78.3	—	82.1	54.4	71.5	86.0	83.4	82.2	33.2
February	84.0	70.9	71.0	72.1	83.3	87.7	87.0	82.4	76.9	—	72.5	66.6	63.3	83.9	77.1	92.2	48.8
March	87.2	68.1	73.5	65.7	86.8	73.8	86.7	82.7	76.2	77.6	75.5	69.2	70.2	83.2	69.5	92.3	55.8
April	87.1	65.8	68.4	69.8	86.0	84.7	88.0	84.3	77.6	80.8	86.2	69.3	73.8	81.0	71.6	82.4	61.6
May	85.9	67.3	83.7	72.3	80.0	84.5	89.5	80.7	82.3	78.8	80.9	75.7	72.0	82.2	77.5	81.1	71.8
June	91.8	78.7	83.7	72.3	87.2	90.6	88.1	78.4	87.3	86.2	84.1	76.4	81.4	85.8	82.8	83.5	73.4
July	93.0	76.0	82.0	73.0	86.1	83.9	84.2	84.2	84.3	79.6	81.9	77.4	79.9	86.1	78.8	83.3	79.1
August	96.0	75.4	78.0	69.4	87.4	88.2	82.2	84.9	90.1	88.2	74.8	80.4	79.1	86.4	83.8	92.3	79.9
September	95.0	84.0	85.1	72.5	89.6	90.4	83.0	88.3	90.0	87.0	80.2	84.5	78.1	89.3	83.8	91.3	80.4
October	91.0	79.1	84.0	71.8	84.2	88.1	87.2	84.2	88.3	86.1	79.0	81.2	76.0	89.1	84.6	90.2	73.7
November	86.5	72.3	80.0	73.0	84.8	85.4	84.2	82.2	80.5	81.9	64.3	68.2	74.6	87.6	74.4	90.6	60.9
December	91.8	82.2	85.2	81.4	87.9	90.4	84.9	81.7	90.8	86.7	67.1	77.1	73.0	88.7	75.9	89.6	57.1
Mean	89.1	74.6	79.4	72.5	86.0	86.3	86.1	83.2	83.5	83.2	77.4	73.3	74.4	85.7	78.6	87.5	64.6

TABLE IV.

Summary of Rainfall in Inches for all Stations in the Gold Coast for the Year 1930.

Month.	Abomposu.	Abakrampa.	Aburi.	Accra.	Achimota.	Agona.	Ajua.	Akpafu.	Akropong (Akwapim).	Akropong (Ashanti).	Akuse.	Amedzofe.	Angu.	Anyinam.	Asamankese.	Asromanso.	Asuansi.	Atwabo.
January	0.65	—	0.06	0.42	1.17	0.00	0.00	0.00	0.15	0.00	0.38	1.02	0.50	1.11	0.42	0.00	1.03	2.58
February	2.75	—	1.06	1.26	1.71	7.46	0.96	2.79	0.79	1.89	0.14	1.96	0.75	12.17	3.21	2.58	1.40	2.17
March	5.51	—	6.20	1.18	0.28	3.61	0.27	3.46	6.79	2.38	3.85	7.22	3.06	6.04	3.45	4.60	2.63	2.94
April	4.23	—	5.83	1.08	1.35	2.66	7.05	5.83	5.13	1.99	5.39	5.12	2.14	6.16	8.65	2.54	3.44	7.63
May	10.58	—	6.37	4.13	3.69	9.54	6.63	9.95	7.92	8.92	6.58	9.44	6.67	9.43	6.11	13.64	7.52	13.29
June	11.38	6.52	11.63	8.52	6.91	14.92	17.81	7.96	5.08	17.87	6.53	9.76	13.00	9.58	11.97	12.45	10.97	22.42
July	3.12	1.87	2.95	1.01	4.04	1.62	0.61	5.86	0.93	0.50	0.25	9.68	1.18	4.87	1.16	2.27	0.65	1.13
August	1.76	0.94	0.65	0.04	0.16	1.09	0.89	0.00	0.14	0.70	0.00	2.90	2.46	1.98	1.41	2.10	1.70	1.44
September	8.41	1.51	3.41	6.53	5.85	5.67	1.22	5.44	1.50	3.02	3.07	4.80	5.22	10.26	3.09	6.14	1.61	2.00
October	8.99	7.05	5.14	2.93	3.15	10.51	6.79	6.94	4.52	4.80	2.62	8.68	6.85	15.79	5.10	8.82	8.19	8.41
November	5.91	2.56	7.61	0.00	0.51	2.01	1.76	6.45	1.58	3.41	2.52	4.84	2.58	3,70	6.68	2.21	3.98	3.55
December	4.74	3.35	2.21	1.29	2.01	1.20	3.15	2.02	1.75	1.55	1.43	1.94	2.60	2.68	2.38	1.32	1.71	6.84
Total	67.98	22.80	53.12	28.39	30.83	60.29	47.14	56.65	36.28	47.03	33.76	67.36	47.01	83.77	53.63	58.67	44.83	74.40
Number of rainy days (0.01″ or more) ...	187	84	155	67	69	127	93	76	77	62	62	131	106	174	127	104	133	169
Highest previous rainfall	74.68	—	73.16	44.20	35.32	77.10	49.54	73.60	47.38	58.23	58.98	72.26	57.03	95.07	77.47	68.36	74.17	105.72
Lowest previous rainfall	51.36	—	32.09	10.84	21.09	59.22	36.81	56.65	29.01	47.03	33.76	67.36	47.01	40.27	50.40	53.02	35.62	74.40

TABLE IV—*continued.*

SUMMARY OF RAINFALL IN INCHES FOR ALL STATIONS IN THE GOLD COAST FOR THE YEAR 1930.

Month.	Axim.	Bawku.	Begoro.	Bekwai.	Bole.	Botoe.	Bunso.	Butre.	Cape Coast.	Dadiasu.	Dafo (Leklebi).	Dentin.	Djoje.	Dunkwa.	Effiduase.	Ejisu.	Ejura.
January	5.49	0.00	3.10	0.00	0.00	0.18	1.77	1.47	0.00	0.25	0.23	0.00	0.00	0.45	0.00	0.00	0.15
February	1.95	0.00	6.51	1.96	0.00	1.55	3.01	0.85	0.60	2.02	3.99	4.05	0.56	1.58	2.57	2.57	0.95
March	3.55	0.05	14.80	3.15	1.57	5.25	4.94	1.45	0.24	2.50	1.87	2.19	3.53	6.77	4.21	5.95	2.09
April	7.13	0.65	4.62	1.05	4.42	3.74	6.38	7.83	4.52	6.02	1.12	3.17	5.51	8.25	3.61	2.01	6.58
May	19.16	0.00	15.60	14.10	4.82	5.57	7.64	11.25	4.74	16.08	6.33	0.05	6.69	6.49	14.35	11.63	13.17
June	27.81	7.30	12.78	10.60	5.19	5.88	7.72	13.79	6.33	9.17	5.53	12.42	10.86	10.69	14.22	9.73	7.82
July	3.43	7.58	4.00	4.46	4.96	4.04	2.99	1.80	1.24	2.91	6.99	6.62	3.90	2.81	1.47	4.29	3.50
August	1.30	8.60	4.50	2.59	3.71	2.17	1.15	1.01	0.03	2.87	3.94	2.73	0.19	1.08	0.89	1.64	0.64
September	2.11	6.03	3.02	6.47	8.84	2.95	5.57	1.78	2.48	7.68	8.24	10.96	1.55	5.76	9.63	8.21	8.56
October	12.30	4.87	9.11	5.61	4.09	8.11	7.19	5.18	7.60	6.48	9.24	7.10	5.18	7.60	8.27	7.89	7.23
November	5.02	1.96	3.50	4.62	0.00	3.20	3.44	1.65	0.90	4.49	5.06	5.27	3.32	8.56	3.41	4.37	5.63
December	7.00	0.21	2.30	3.69	0.11	1.36	1.01	1.89	2.08	1.65	1.54	3.81	1.52	1.48	3.66	0.81	0.18
Total	96.25	37.25	83.84	58.30	37.71	44.00	52.81	59.95	30.76	62.12	54.08	64.37	42.87	61.52	66.29	59.10	56.50
Number of rainy days (0.01″ or more)	133	50	81	109	70	94	116	105	74	178	121	94	50	128	90	90	86
Highest previous rainfall ...	109.65	40.25	84.56	104.90	54.62	45.01	72.86	75.47	56.25	69.47	55.27	91.04	42.87	77.91	66.68	64.45	80.75
Lowest previous rainfall ...	47.64	37.25	50.43	46.21	37.31	44.00	52.81	51.76	30.19	41.30	54.08	64.37	41.60	45.55	65.02	56.90	47.45

TABLE IV—*continued.*

SUMMARY OF RAINFALL IN INCHES FOR ALL STATIONS IN THE GOLD COAST FOR THE YEAR 1930

Month.	Enchi.	Esiama.	Esuasu.	Gambaga.	Goaso.	Half Assini.	Ho.	Honuta.	Imprim.	Jemma.	Juaso.	Jumapo.	Kajebi.	Keta.	Kete-Kratchi.	Kibi.	Kintampo.	Kodia_Kese.
January	0.92	—	2.46	0.00	0.00	1.85	1.80	1.64	0.00	0.60	0.02	—	0.45	0.00	0.70	0.45	0.00	0.00
February	0.92	—	2.31	0.07	1.64	1.42	2.65	0.65	4.06	0.00	5.70	—	0.82	0.50	2.31	3.33	0.97	2.53
March	5.70	3.09	5.03	0.70	7.43	0.72	10.87	5.77	8.54	5.40	4.22	—	6.69	3.54	3.25	4.92	4.07	2.26
April	4.92	10.20	6.76	0.70	1.97	5.71	3.41	3.20	5.51	3.37	4.78	—	3.40	2.90	7.31	4.11	5.91	2.26
May	5.65	10.20	8.86	4.54	10.12	15.30	7.95	5.42	20.51	6.54	12.82	—	9.74	7.65	13.14	4.81	9.92	9.07
June	5.99	17.10	0.63	3.80	12.70	26.60	7.11	11.34	13.17	15.33	7.47	—	8.33	8.70	8.29	9.67	10.02	15.41
July	4.72	1.15	1.42	6.11	3.99	4.87	3.97	5.60	11.37	4.70	2.92	—	2.98	2.17	9.37	5.20	4.07	3.66
August	2.57	2.27	2.24	4.80	1.38	2.63	3.49	5.81	2.61	1.21	1.55	—	1.72	0.00	8.31	0.79	1.65	1.30
September	10.31	2.78	4.09	6.21	7.93	1.61	3.31	10.70	9.19	3.81	9.57	—	8.12	3.33	9.72	5.22	14.80	6.27
October	5.59	8.34	9.32	4.23	5.65	8.99	9.44	18.40	9.98	8.49	11.28	—	6.16	7.35	18.95	7.12	9.16	4.06
November	4.43	4.29	3.96	0.00	4.47	7.59	2.85	4.43	3.28	7.97	3.41	4.78	0.61	0.88	2.77	4.13	2.70	4.34
December ...	2.44	7.14	3.32	0.34	0.00	14.83	0.32	2.03	2.06	4.60	1.66	2.22	2.20	0.45	2.53	5.05	0.09	0.50
Total	54.16	66.38	60.40	31.50	57.23	92.12	57.17	74.99	90.27	62.02	65.40	7.00	51.22	37.47	86.65	54.80	63.36	51.66
Number of rainy days (0.01″ or more) ...	100	166	95	75	128	142	84	109	127	114	142	16	122	47	77	129	117	80
Highest previous rainfall	54.16	—	102.63	56.47	59.50	92.12	60.52	74.99	90.27	75.37	76.12	—	68.71	51.44	99.95	79.90	100.58	85.83
Lowest previous rainfall	38.31	—	60.40	19.91	44.94	61.63	44.11	69.60	66.82	62.02	53.42	—	51.22	13.88	43.61	45.77	48.87	51.66

TABLE IV—*continued.*

SUMMARY OF RAINFALL IN INCHES FOR ALL STATIONS IN THE GOLD COAST FOR THE YEAR 1930.

Month.	Koforidua.	Kpandu.	Kpeve.	Kumasi.	Lawra.	Mampong (Ashanti).	Mansu.	Mpayo	Mpraeso.	Mpenase.	Navrongo.	Nkawkaw	Nsawam.	Oda.	Odumase.	Otikrom.	Otrokpe.
January	0.32	0.77	1.77	0.00	0.00	0.00	0.07	2.04	0.94	0.65	0.00	0.42	0.20	0.00	0.31	0.00	1.48
February	3.57	2.56	2.24	2.48	0.00	6.67	2.13	1.11	1.39	0.65	0.00	0.85	0.70	2.17	0.00	2.58	3.62
March	6.68	2.55	3.27	6.44	0.93	3.86	2.17	4.01	3.71	2.46	0.06	2.99	5.08	6.24	3.47	6.70	6.75
April	5.39	4.15	3.81	2.50	4.65	3.99	3.85	3.60	2.03	4.81	2.71	4.95	6.28	5.15	2.00	2.11	9.51
May	9.12	7.45	5.05	8.47	9.91	9.53	6.79	12.11	8.56	11.08	5.89	10.39	5.57	7.67	7.09	9.89	6.69
June	9.50	5.25	7.45	10.72	7.51	6.63	16.75	8.44	8.25	9.48	9.86	7.53	12.73	11.01	6.07	11.71	6.65
July	1.78	3.15	3.53	3.34	4.67	5.00	0.72	6.62	5.57	2.15	7.22	6.80	3.80	3.64	2.41	4.38	3.76
August	1.06	2.41	3.27	1.47	14.48	0.20	3.97	8.22	3.41	1.33	11.09	2.12	0.50	2.61	0.70	2.63	3.65
September	4.25	8.18	9.39	7.31	10.88	11.05	2.49	11.46	11.46	1.87	6.98	9.25	3.00	6.12	6.66	6.44	6.27
October	6.60	11.28	7.10	5.03	3.66	9.12	7.94	6.05	11.28	5.05	5.30	12.49	3.29	6.13	3.18	7.25	6.84
November	5.28	3.44	2.13	1.67	0.41	1.90	2.59	0.57	4.13	2.67	0.00	2.51	5.20	8.43	10.24	4.35	3.21
December	1.98	2.84	0.42	1.35	0.00	1.32	2.06	1.07	3.86	4.05	0.00	2.24	0.80	1.44	0.23	0.23	0.96
Total	55.53	54.03	49.43	50.78	58.10	59.27	51.53	65.34	64.69	46.25	49.11	62.54	47.15	60.61	42.36	58.27	59.39
Number of rainy days (0.01″ or more)	149	106	116	110	80	117	150	115	158	75	70	139	59	116	72	85	55
Highest previous rainfall ...	59.50	57.79	53.65	70.40	58.10	59.96	83.70	68.28	85.26	75.72	49.11	68.51	55.40	83.75	49.77	77.72	59.39
Lowest previous rainfall ...	44.94	54.03	49.43	40.07	36.43	52.51	46.90	65.28	57.55	46.25	28.66	60.68	39.33	43.61	37.10	55.48	45.56

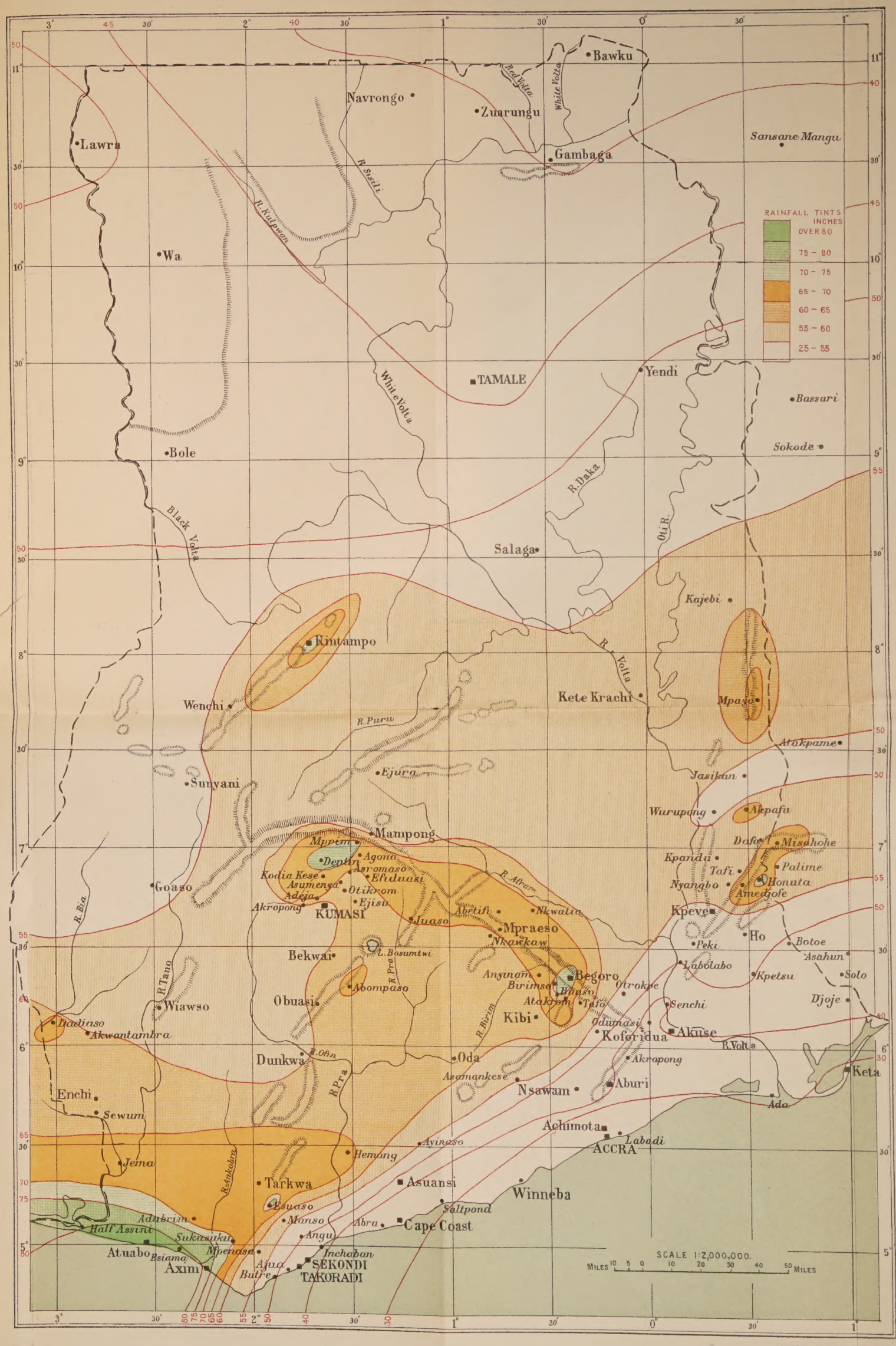
TABLE IV—*continued.*

SUMMARY OF RAINFALL IN INCHES FOR ALL STATIONS IN THE GOLD COAST FOR THE YEAR 1930

Month.	Salaga.	Saltpond.	Sekondi.	Sunyani.	Tafo.	Takoradi.	Tamale.	Tarkwa.	Wa.	Wenchi.	Wiawso.	Winneba.	Yendi.	Zuarungu.
January	0.00	0.07	0.29	0.00	0.10	0.01	0.00	1.39	0.00	0.02	0.00	0.26	0.00	0.00
February	1.28	0.55	0.54	0.72	4.54	0.64	0.78	4.65	0.00	0.64	1.66	1.20	1.06	0.00
March	1.48	1.37	0.46	3.56	5.35	1.03	1.85	2.61	0.37	2.33	4.10	0.18	1.09	0.04
April	2.14	2.18	4.45	2.43	3.68	5.45	3.57	4.81	2.11	2.46	4.73	2.91	3.30	2.12
May	8.72	5.78	6.75	6.55	6.64	7.53	9.29	12.24	9.55	11.82	8.50	1.80	6.97	4.28
June	2.54	3.28	14.02	7.68	10.67	11.21	3.63	18.51	8.84	7.14	12.36	6.73	3.93	8.31
July	7.23	0.38	0.46	1.14	4.07	0.10	6.46	4.07	3.36	1.23	2.90	2.00	8.32	6.86
August	5.24	0.43	1.11	1.52	2.34	0.75	8.63	2.51	8.59	1.58	2.53	0.11	3.58	11.49
September	9.56	3.45	0.93	18.42	7.74	0.84	8.12	5.01	11.36	15.38	6.02	2.36	8.12	9.15
October	5.13	1.81	8.45	16.96	9.40	2.45	3.88	7.86	3.09	9.17	8.79	5.75	3.42	2.79
November	2.84	1.80	1.20	2.48	1.36	1.72	0.32	8.66	0.00	2.04	2.30	0.00	0.00	0.11
December	0.04	2.76	4.00	0.00	2.00	2.73	0.89	2.93	0.00	0.60	0.07	1.07	0.40	0.00
Total	46.21	23.86	42.66	61.46	57.89	33.46	47.42	75.25	47.27	55.41	54.01	24.37	40.19	45.15
Number of rainy days (0.01″ or more)	78	50	72	66	95	107	104	177	65	79	144	65	58	77
Highest previous rainfall ...	64.52	43.80	57.76	69.47	68.30	40.47	61.77	75.25	57.21	60.95	112.76	44.27	67.12	51.62
Lowest previous rainfall ...	37.79	19.73	32.98	41.30	57.89	33.46	32.36	29.08	29.08	53.40	40.14	14.60	40.19	37.93

DEPARTMENT OF AGRICULTURE.

Mean Distribution of Rainfall
(to the end of 1930)



SURVEY H.Q. ACCRA, 1931.

DEPARTMENT OF AGRICULTURE—(GOLD COAST)
MEAN DISTRIBUTION OF RAINFALL
TO THE END OF 1930.

List of Rainfall Recording Stations.

	Name.	Amount. Inches.	No. of years of record.
1.	Abomposu	67.49	9
2.	Abra	33.02	7
3.	Aburi	47.74	40
4.	Accra	27.65	44
5.	Achimota	27.76	6
6.	Ada	32.05	7
7.	Adeja	70.65	1
8.	Adubrim	68.46	3
9.	Agona (Ashanti)	64.82	5
10.	Ajua	45.38	11
11.	Akpafu	65.12	2
12.	Akropong (Akwapim)	38.76	4
13.	Akropong (Ashanti)	51.04	2
14.	Akuse	40.75	16
15.	Akwatambra	60.00	—
16.	Amedjofe	69.81	2
17.	Angu	52.16	5
18.	Anyinam	66.66	23
19.	Asamankese	58.83	8
20.	Asromaso	55.39	4
21.	Asuansi	49.38	22
22.	Atakrom	69.69	5
23.	Atwabo	83.60	4
24.	Axim	79.91	16
25.	Ayinasu	55.17	7
26.	Bawku	38.79	4
27.	Begoro	71.32	9
28.	Bekwai	62.44	17
29.	Birimso	70.45	13
30.	Bole	45.87	4
31.	Botoe	44.50	2
32.	Bunso	62.83	2
33.	Butri (Seysie)	54.17	10
34.	Cape Coast	38.27	9
35.	Dadiasu	65.94	9
36.	Dafo (Leklebi)	54.67	2
37.	Dentin	70.38	4
38.	Djoje	41.73	2
39.	Dunkwa	57.70	16
40.	Effiduasi	66.04	4
41.	Ejisu	61.56	5
42.	Ejura	57.47	15
43.	Enchi	54.16	1
44.	Esiama	(66.38)	(10 months)
45.	Esuasu	77.95	5
46.	Gambaga	37.73	6
47.	Goaso	52.09	7
48.	Half Assini	79.42	9
49.	Hemang	67.08	10
50.	Ho	54.98	9
51.	Honuta	72.08	2
52.	Inchaban	41.38	1
53.	Jema	68.69	2
54.	Juaso	65.42	15
55.	Kajebi	59.96	2
56.	Keta	28.06	25
57.	Kete-Krachi	57.86	12
58.	Kibi	63.46	18
59.	Kintampo	70.14	16
60.	Kodia-Kese	64.13	5
61.	Koforidua	52.47	9
62.	Kpando	55.91	2
63.	Kpetsu	52.38	4
64.	Kpeve	51.52	4
65.	Kumasi	58.16	24
66.	Labadi	25.17	7
67.	Labolabo	50.81	8
68.	Lawra	54.64	4
69.	Mampong (Ashanti)	57.43	5
70.	Mansu	58.87	17
71.	Mpayo	66.81	2
72.	Mpenase	59.56	6
73.	Mpraeso	68.07	13
74.	Mprim	73.03	5
75.	Navrongo	44.64	4
76.	Nkawkaw	64.18	5
77.	Nkwantia	65.00	10
78.	Nsawam	45.32	5
79.	Obuasi	62.03	4
80.	Oda	60.19	16
81.	Odumasi	38.82	6
82.	Otikrom	61.41	5
83.	Otrokpe	52.47	2
84.	Peki Blengo	52.09	13
85.	Salaga	51.56	16
86.	Saltpond	31.63	16
87.	Sekondi	40.74	27
88.	Senchi	40.00	—
89.	Sukusuku	70.00	—
90.	Sunyani	54.99	16
91.	Tafo	62.02	5
92.	Takoradi	33.46	1
93.	Tamale	42.79	21
94.	Tarkwa	68.42	27
95.	Wa	47.02	14
96.	Wenchi	55.65	9
97.	Wiawso	56.76	13
98.	Winneba	28.14	9
99.	Yendi	50.78	9
100.	Zuarungu	43.48	13

German Figures.

1.	Asahun	45.16	6
2.	Atakpame	53.46	9
3.	Bassari	51.20	—
4.	Jasikan	53.57	6
5.	Palime	58.37	6
6.	Misahohe	65.38	9
7.	Nyangbo	56.26	8
8.	Sansane-Mangu	42.20	—
9.	Sokode	52.03	9
10.	Solo	43.80	9
11.	Tafi	55.49	9
12.	Wurupong	54.02	1

PREVIOUS BULLETINS.

1. Control of Termites or White Ants in Buildings 1925
2. Rainfall of the Gold Coast 1926
3. Preliminary Study of Life History of Sahlbergella 1926
4. Yields of Cacao on Experiment Stations 1926
5. Collar Crack of Cacao 1927
6. Economic Significance of Cacao Pod Diseases ... 1927
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8. Plantation Oil Palm Industry in the East ... 1927
9. Sugar, Snow Rubber, Quinine, Nipa Palm in the East 1927
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11. Cacao Diseases prescribed under Pests Ordinance 1927
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14. Yields of Funtumia Rubber 1928
15. Climatology of the Gold Coast 1928
16. Year-Book, 1928 1929
17. Studies in Co-operation in India and Ceylon ... 1929
18. Yields of Hevea Brasiliensis 1930
19. Second Conference of West African Agricultural Officers (Proceedings) 1930
20. Second Conference of West African Agricultural Officers (Papers) 1930

Prospectus of Agricultural Training Centre (Kumasi) 1930

1929 1930